A LAND CAPABILITY STUDY OF THE SHIRE OF MITCHELL

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Further Information

This report has been prepared for the Shire of Mitchell Council, to assist with broad scale planning. The information in the report has been derived from air photo interpretation and a limited number of representative field sites. The scale of mapping adopted has necessitated some generalisations from the site information collected. While the ratings indicate the likely performance of the various types of land for a specific use, site specific information may be required for on-site planning. The precision of mapped boundaries is affected by the scale of the map. Any enlargement of the map is discouraged because it will distort information and will not improve accuracy.

Any queries in relation to the Land Capability Assessment process may be directed to the Centre for Land Protection Research, Bendigo, phone (054) 446777.

Maps relating to this study can be viewed at the Shire of Mitchell Municipal Offices, the Broadford office of the Department of Natural Resources and Environment, or the Centre for Land Protection Research, Bendigo.

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USER GUIDE

The user guide is designed to assist document users in finding and cross referencing information contained within this report. Each section of the report is listed below with a brief description of the contents and the relationship to other sections.

Summary: The Summary contains a listing of the land capability classes determined for specific types of land use, in each map unit within the project area. A brief discussion of the project area and important land management issues is also provided. Refer to Section 4 and Appendix B for a detailed description of map units and capability classes.

Section 1: The Introduction highlights the location of the Mitchell Shire and the specific objectives of this study.

Section 2: The Land Capability Assessment section describes the DNRE approach to land capability assessment. Tables 2.1 and 2.2 highlight the limitations to development and management guidelines for each land capability class. The land use rating tables are contained in Tables 2.3 to 2.8; they are used to determine the capability classes for each map unit. Refer to Section 3 and Appendix A for a further description of the parameters that influence each form of land use, and Appendix B for the capability class assigned to each parameter in each map unit.

Section 3: The Land Management Guidelines section describes important landform and soil characteristics which place limitations on land use, and explains how improved land management may reduce or overcome the perceived limitations. Refer to Appendix A for a further description of the parameters that influence land use.

Section 4: The Map Unit Descriptions section contains a broad review of related map units and discusses the common limitations to land use. This is the core section of the report and contains specific map unit descriptions and land capability assessments for each map unit. A dual page format provides general and specific landform and soil information, including susceptibility to land degradation.

Appendices: There are five appendices contained in the report. Appendix A describes the parameters that influence land use and outlines the methods used to determine the capability class. Appendix B contains the land capability classes for each land use and each map unit. Appendix C describes the methodologies used for the land capability assessment. Appendix D lists the physical and chemical results of major soil types in each map unit. Appendix E provides a method of establishing recharge (soil permeability) values for various soil types.

SUMMARY

This study describes in detail the land present in the Shire of Mitchell and provides information relevant to land use planning and assessment.

The new Shire of Mitchell is an amalgamation of part or all of the former Shires of Kilmore, Wallan, Broadford, Pyalong, McIvor and Seymour. The Shire is 2870 km^2 in area and is located on the fringe of the northern growth corridor of Melbourne. Population growth within the Shire has increased considerably in the past decade, and this trend is expected to continue. The demand for urban and rural residential development has closely followed population growth. Inappropriate subdivisions and development have occurred in the past in Victoria, resulting in unnecessary development and maintenance costs, and extensive land and water degradation. The use of Land Capability information will assist the Shire of Mitchell in identifying land with major physical limitations for urban and rural development, aid decision making where competing land uses occur, and will be invaluable in the preparation or revision of planning strategies for future development.

The greatest pressure for residential development is centred within the major townships of Kilmore, Seymour and Broadford. The expansion of these townships into adjacent farmlands will require special consideration of the lands physical limitations and capability for development.

Pressure for rural residential development also occurs close to established townships, however development is more widespread and covers most areas of the Shire. The protection of good quality agricultural land is becoming increasingly important as rural residential development is encroaching upon, and fragmenting, the remaining agricultural lands. Identification of good quality agricultural land will enable planning strategies to be developed to protect it.

Large tracts of public land are present in the former Shires of Broadford and Seymour. These public land areas are utilised for forestry, recreation and nature conservation purposes.

The Shire has a diverse range of landscapes including steep to gently undulating sedimentary hills, dissected granitic plateaus with gentle to steep slopes, undulating volcanic plains, and various alluvial floodplains associated with major rivers and creeks. Climatic variation is pronounced, with a higher rainfall and longer growing season present in the southern portion of the Shire.

Much of the Shire, particularly the steep granitic and sedimentary areas, are highly susceptible to various land degradation problems. Sheet and gully erosion is a major concern on all steep to moderate slopes in the granite and sedimentary terrain. The incidence of gully erosion and salting is also increasing in the gentle sedimentary terrain. Much of the current land degradation problems can be attributed to inappropriate land use and management.

A land capability study has recently been completed for the former Shire of Broadford. This information has been incorporated into the Shire of Mitchell study to provide consistent representation of land capability information across the new shire.

A previous study 'A Reconnaissance Survey of the Middle reaches of the Goulburn River.' edited by L.A. White (1990) has provided background information on soils and geomorphology for this study.

The Department of Natural Resources and Environment and the National Landcare Program are jointly funding land capability studies within local government areas. The Shire of Mitchell has requested that the Department of Natural Resources and Environment undertake a study, to update land capability coverage across all districts of the Shire.

Table i.i Summary of land capability classes.

SYMBOLS			LAND CAPABILITY CLASSES			
1:100 000	**1:25 000**	**Description**	**Agriculture**	**Urban development**	**Rural residential development**	**Susceptibility to erosion**
Qa	**Qa1**	Quaternary alluvium, Goulburn River floodplain	3	5	5	2
	Qa2	Quaternary alluvium, Sunday, McIvor, Sugarloaf and Darbyminga Creek floodplains	3	5	5	3
	Qa3	Quaternary alluvium, Goulbourn River terrace	3	3	3	3
Qap	**Qap1**	Quaternary alluvium, Whiteheads Creek alluvial plain	3	4	4	4
	Qap2	Quaternary alluvium, Wallan alluvial plain	5	5	5	2
Qvs	**Qva**	Quaternary volcanics, steep crest	4	4	5	3
Qvm	**Qvc**	Quaternary volcanics, moderately steep slope	4	4	5	5
	Qvd	Quaternary volcanics, moderate slope	4	3	5	5
Qvg	**Qve**	Quaternary volcanics, gentle crest	4	3	5	3
	Qvf	Quaternary volcanics , gentle slope	3	3	5	3
	Qvg	Quaternary volcanics, very gentle slope	4	5	5	3
	Qvh	Quaternary volcanics, drainage depression	3	4	4	3
Qvp	**Qvp**	Quaternary volcanics, plain	4	5	5	3
Tsm		Tertiary alluvial sediments, moderate slope	4	-	-	3
Tsg		Tertiary alluvial sediments, gentle crest, gentle slope and drainage depression	4	-	-	2
Dgs	**Dga**	Devonian granodiorite, steep crest	5	5	5	4
	Dgb	Devonian granodiorite, steep slope	5	5	5	5
Dgm	**Dgc**	Devonian granodiorite, moderately steep slope	4	4	5	5
	Dgd	Devonian granodiorite, moderate slope	4	4	4	5
Dgg	**Dge**	Devonian granodiorite, gentle crest	4	4	5	4
	Dgf	Devonian granodiorite, gentle slope	3	3	4	5
		Devonian granodiorite, gentle slope and drainage depression	3	-	-	5
Sss	**Ssa**	Silurian/Devonian sediments, steep crest/ridge	5	5	5	5
	Ssb	Silurian/Devonian sediments, steep slope	5	5	5	5
Ssm	**Ssc**	Silurian/Devonian sediments, moderately steep slope	5	4	5	5
	Ssd	Silurian/Devonian sediments, moderate slope	5	4	5	5
Ssg	**Sse**	Silurian/Devonian sediments, gentle crest	5	3	5	4
	Ssf	Silurian/Devonian sediments, gentle slope	3	3	3	3
	Ssg	Silurian/Devonian sediments, very gentle slope	3	3	3	3
	Ssh	Silurian/Devonian sediments, drainage depression	3	4	4	4
Oss		Ordovician sediments, steep crest and slope	5	-	-	5
Osm		Ordovician sediments, moderately steep slope	4	-	-	4
Osg		Ordovician sediments, gentle slope and drainage depression	3	-	-	4

Note: Please refer to Section 4 (Detailed Map Unit Descriptions and Capability Ratings) for further information.

PREFACE

The Department of Natural Resources and Environment (DNRE) has been involved in formal land capability assessment studies since the early 1970s. The Land Capability Section of the (then) Soil Conservation Authority established the framework for the conduct of formal land capability studies upon which this more recent work is based. This framework included rating tables for some thirty activities. Ratings for various activities were presented as thematic maps, or combined into ratings for various land uses, depending upon the needs and abilities of the client.

A survey of the awareness, needs and willingness of Victorian rural municipalities to use land resource information has indicated a general appreciation of the value of sound land resource information for the preparation or revision of long-term planning strategies. Subsequently, a submission seeking funds from the National Soil Conservation Program was prepared. It was proposed to undertake detailed land capability studies in municipalities with significant pressures for change in land use to more intensive uses, where there was significant existing or potential land degradation issues, or where better quality agricultural land was under threat of development for residential purposes.

The primary objective of this study has been to provide the Shire of Mitchell with detailed land resource information, consisting of base data on the nature of the land and of assessments of the likely performance of the land under various activities. This information can underpin many land use and management decisions by the municipal authority, both now and in the future. In doing so, many of the problems and unexpected costs incurred through inappropriate land use can be avoided.

1. INTRODUCTION

1.1 Introduction

Land varies considerably in its basic characteristics and its response to the demands made upon it. Such demands include the production of food, fibre, water, and development for residential, industrial and recreational purposes.

Planners need to match the requirements of land use with the capability of the land to sustain that use and avoid land degradation. Prior knowledge of soil and land limitations can prevent unnecessary and costly mistakes. Information obtained through land capability assessments can provide the necessary data to assist local government with planning decisions and the preparation of planning strategies for the future.

Planning schemes developed and implemented by local government provide an effective means of managing changes in land use. A planning scheme may prohibit or place conditions on land use not well suited to a land type.

This report provides land resource information for broad-scale planning within the Shire of Mitchell. It does not provide recommendations for land use and no allowance has been made for social or economic considerations which may influence planning proposals. It is primarily an examination of potential consequences and levels of management required for a range of land uses.

1.2 Location

The Shire of Mitchell is dissected by the Hume highway to the north of Melbourne. The main population centres of the Shire include Seymour, Broadford, Kilmore and Wallan (Figure 1.1). It has an area of approximately 2870 km^2.

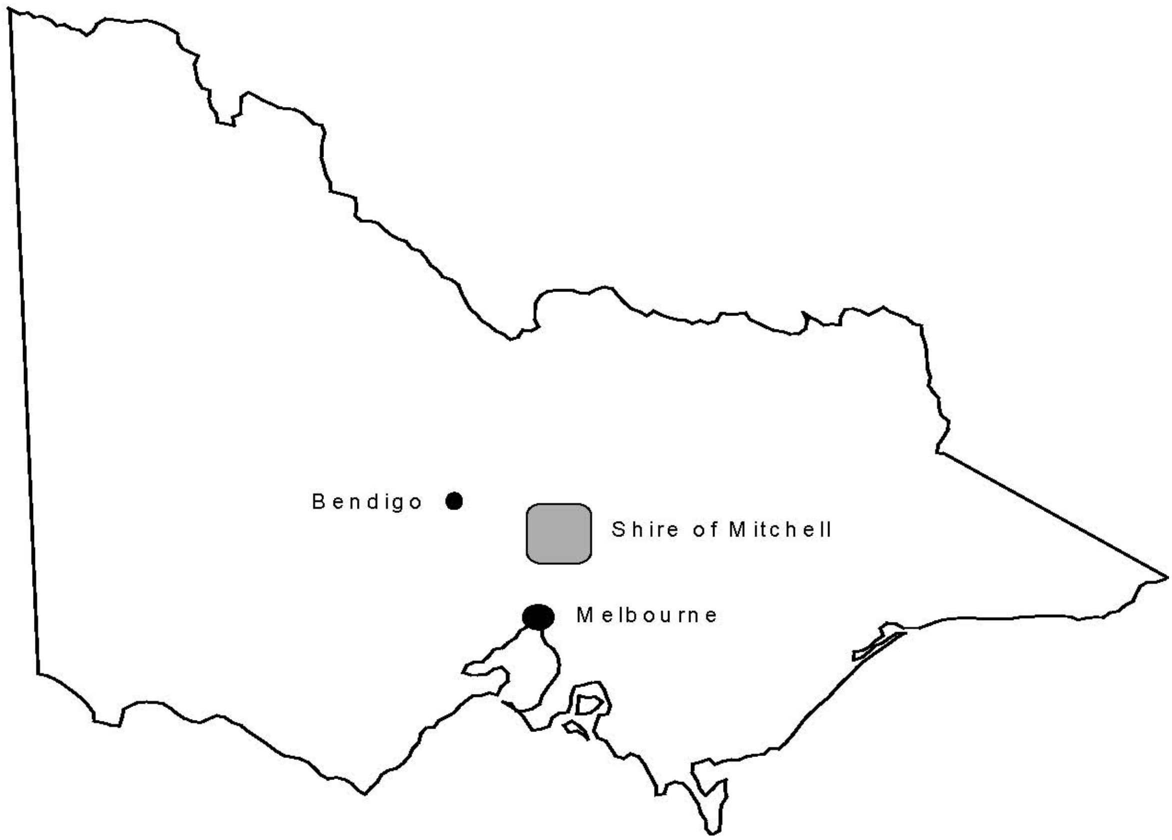


Figure 1.1 Location of the Shire of Mitchell

1.3 Purpose of study

To provide land resource information and land capability assessment to the Shire of Mitchell Council to support regional planning and development, protect areas of special value, and to minimise the impact of land degradation.

More specifically:

1. To prepare a report describing the freehold land in the Shire of Mitchell at a scale of 1:25,000 and 1:100,000 (excluding existing urban areas and large blocks of public land), identifying dominant land types (including soil types and topography), climatic zones and other features relevant to the assessment of the capability of the land.

2. To prepare a land capability analysis for each dominant land type identified in the Shire of Mitchell, based on the following standardised rating tables:

    - agriculture
    - effluent disposal (septic tanks)
    - earthen (farm) dams
    - secondary roads
    - building foundations

3. To provide the following colored thematic maps at 1:25,000 scale of the Kilmore, Wallan, Broadford and Seymour strategic areas:

    - map units
    - agriculture
    - urban residential development
    - rural residential development

4. To provide the following colored thematic map at 1:100,000 scale of the Shire of Mitchell:

    - map units
    - agriculture
    - susceptibility to erosion

5. To assist the Mitchell Shire Council in the incorporation of this land resource information into its planning strategies.

2. LAND CAPABILITY ASSESSMENT

2.1 Philosophy and principles

Land capability assessment is a rational and systematic method of determining the ability of land to sustain a specific use and level of management, without causing significant long-term degradation.

The objectives of land capability assessments are:

i) to assist land managers and land use planners to identify areas of land with physical constraints for a range of nominated land uses.

ii) to identify management requirements that will ensure a particular land use can be sustained without causing significant on-site or off-site degradation to the land, or to water quality.

To achieve these objectives it is necessary to know the natural characteristics of the land and understand the effects that a proposed land use may have on the land and the water derived from it.

Land capability assessments analyse basic landform and soils information to determine the ability of the land to sustain a desired land use. A strength of the methodology lies in its association with land systems since the results can be extrapolated, with care, to similar land components and land systems in other areas.

The ratings provided by a land capability assessment are not intended to restrict development of land, but rather to identify the principal constraints of that land for a specified land use. It is a matter for the land manager or municpal planner to decide if the cost of overcoming the constraints is justified. Where particularly severe physical constraints exist, the planning authority has the option of excluding land from a particular use, or permitting the use only under strict conditions. The placement of conditions on development permits is quite a proper exercise of planning responsibility.

2.2 Land resource mapping - methodology and constraints

The main objective of land resource mapping is to identify areas of land that are uniform with respect to the characteristics which affect land use. These areas of land will have a similar land use capability for a nominated use and are likely to respond in a similar way to management. By identifying areas of land with a limited range of variability, the resultant map provides the basis for land capability assessment (for specific methodologies, refer to Appendix C).

Mapping an area of land can be a complex task as many differences arise due to interactions between climate, geology and topography. While it is possible to measure and determine some of the land characteristics such as slope, rock outcrop, and soil type, other characteristics such as site drainage and permeability, are less easily determined.

The following procedure has been adopted for this study:

i) The geological boundaries are obtained from existing maps and verified in the field at the appropriate mapping scale.

ii) The broad landform pattern and the landform elements are identified from air-photos using a binocular stereoscope. The map units are derived from this information.

iii) Extensive field verification of map units ensure that map units are consistent with respect to parent material, slope, position in the landscape, soil type, drainage and native vegetation.

iv) A representative site for each map unit is selected, to record general landform and site information. The incidence of any land degradation in each map unit is also recorded.

v) A soil pit or large exposure of the soil profile is prepared at each selected site. Detailed soil profile information is recorded. Colour photographs are taken and soil samples collected for physical and chemical analyses (see Appendix D and the corresponding tables for each Land Unit in Section 4, for details).

vi) The permeability of the soil profile is measured when the soils are near field capacity (see Appendix C).

vii) The map unit boundaries are entered into a Geographic Information System where the data is combined with base-map information on roads, contours and streams to produce a final base map of the study area with appropriate headings and legend.

viii) Land capability ratings for those land uses relevant to the study are derived from the climatic, land and soil data available for each map unit based on standardised rating tables. Separate land capability assessment maps are prepared for the specified land uses.

ix) A report is prepared to provide accompanying land resource information and methodology for the land capability maps.

2.3 Assessment procedure

A land capability rating table lists key land characteristics such as slope, site drainage, or soil depth, which may affect the ability of the land to support a specified land use. These land characteristics are quantified and graded into classes for the land use being assessed. Each map unit within the study area is given a capability class according to the tables shown in Section 2.4.

It is the most limiting factor that determines the Capability Class for the map unit. This is related to the degree of limitation for that land use and the general level of management that will be required to minimise degradation.

A Capability Class of one represents essentially no physical limitations to the proposed land use whilst a Class of five indicates a very low capability to sustain the land use. Limitations in Class five generally exceed the current level of management skills and technology available. Severe deterioration of the environment is likely to occur if development is attempted. A Class of two, three or four will require increasing levels of management to sustain the particular land use, otherwise the environment will deteriorate

Separate class descriptions are prepared for agriculture (Table 2.1) and other land uses (Table 2.2). Due to the scale of mapping adopted (1:25000), the inherent variability within some landscapes may result in the presence of small unrepresentative areas within map units. In some cases, these areas will have an improved capability class exceeding that of the overall map unit. An opportunity may therefore exist to distinguish and utilise land with fewer constraints for a chosen development. This is most likely where allotment sizes exceed five ha. Detailed site inspection is required under these circumstances

2.4 Land capability rating tables

Each land capability rating table (refer Tables 2.3, 2.4, 2.5, 2.6, 2.7 and 2.8) contains criteria which will strongly influence the ability of the land to sustain the desired land use. The limitations distinguishing each land capability class from one to five are also presented for comparison.

There has been no attempt to rank the criteria in order of importance. The objective of having classes is to identify the kind of limitation and its severity. It is recognised that criteria may interact, but an underlying objective of this study is to provide the information in a useable form, rather than have a convoluted series of alternative pathways that would be too complex for the intended user to follow.

Where there are known interactions between different criteria, it is the responsibility of the planner or land manager to assess the importance of the limiting factor(s) and to determine the need for management or additional financial input to overcome the limitation.

Theoretically a single diagnostic land quality could be found and used to rate land performance, but there is the risk of such a feature masking the true parameters that affect the land use, thus preventing a change to a more appropriate land use or level of management. Land use and land management practices will continue to change and if the community is concerned about long-term sustainability of specific land uses, then the limitations of the soil, the various processes of land degradation, and the possibility of off-site effects, must be recognised. Once a limitation to land use is identified, steps can be taken to overcome or minimise the long-term effect of land degradation that would result if the land use was continued.

Table 2.1 Land capability classes for agriculture.

CLASS	CAPABILITY	DEGREE OF LIMITATION
Class 1	Very good	Can sustain a wide range of uses including an intensive cropping regime. Very high levels of production possible with standard management levels.
Class 2	Good	Moderate limitations to agricultural productivity, overcome by readily available management practices.
Class 3	Fair	Can sustain agricultural uses with low to moderate levels of land disturbance such as broadacre cultivation in rotation with improved pastures. Moderate to high levels of production possible with specialist management practices such as minimum tillage.
Class 4	Poor	Low capacity to resist land disturbance such as cultivation. Moderate production levels possible with specialist management such as improved pasture establishment with minimum tillage techniques. Recommended for low disturbance agriculture such as grazing or perennial horticulture.
Class 5	Very poor	Very low capability to resist disturbance. Areas of low productive capacity. Minimal grazing levels or non-agricultural uses recommended.

Note: Land is assessed for agricultural production on the basis of climate, topography, and the inherent characteristics of the soil. Climate differs from topography and soil features in that it is a regional parameter rather than site specific. The capability table identifies the versatility and potential productivity of an area for a range of agricultural uses, and highlights the necessary level of management required to sustain the land use.

These agricultural ratings are for comparative purposes only and should not be used as a basis for detailed property planning.

Table 2.2 Land capability classes for effluent disposal, earthen (farm) dams, secondary roads and building foundations.

CLASS	CAPABILITY	DEGREE OF LIMITATION TO DEVELOPMENT	GENERAL DESCRIPTIONS AND MANAGEMENT GUIDELINES
Class 1	Very good	The limitation of long term instability, engineering difficulties or erosion hazards do not occur or they are very slight.	Areas with high capability for the proposed use. Standard designs and installation techniques, normal site preparation and management should be satisfactory to minimise the impact on the environment.
Class 2	Good	Slight limitations are present in the form of engineering difficulties and/or erosion hazard.	Areas capable of being used for the proposed use. Careful planning and the use of standard specifications for site preparation, construction and follow up management are necessary, to minimise the impact of the development on the environment.
Class 3	Fair	Moderate engineering difficulties and/or a moderately high erosion hazard exists during construction.	Areas with a fair capability for the proposed use. Specialised designs and techniques are required to minimise the impact of the development on the environment.
Class 4	Poor	Considerable engineering difficulties during development and/or a high erosion hazard exists during and after construction.	Areas with poor capability for the proposed use. Extensively modified design and installation techniques, exceptionally careful site preparation and management are necessary to minimise the impact of the development on the environment.
Class 5	Very poor	Long term severe instability, erosion hazards or engineering difficulties which cannot be practically overcome with current technology.	Performance of the land for the proposed use is unsatisfactory. Severe deterioration of the environment will occur if development is attempted in these areas.

Table 2.3 Land capability assessment for agriculture.

PARAMETERS INFLUENCING AGRICULTURAL PRODUCTION		LAND CAPABILITY RATINGS				
		Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
C: Climate	Length of growing season (months)	12 - 11	10 - 8	7 - 5	4 - 2	< 2
T: Topography	Slope (%)	< 1	1 - 3	4 - 10	11 - 32	> 32
S: Soil	Condition of topsoil *	25 - 21	20 - 16	15 - 11	10 - 6	5 - 1
	Depth of topsoil (mm)	> 300	300 - 160	150 - 110	100 - 50	< 50
	Depth to rock/hardpan (m)	> 2.0	2.0 - 1.5	1.5 - 1.0	1.0 - 0.5	< 0.5
	Depth to seasonal watertable (m)	> 5.0	5.0 - 2.0	2.0 - 1.5	1.5 - 1.0	< 1.0
	Total amount of water (mm) available to plants *	> 200	200 - 151	150 - 101	100 - 51	50 - 0
	Index of permeability/rainfall *	Very high	High	Moderate	Low	Very low
	Dispersibility of topsoil (Emerson) *	E6, E7, E8	E3(1), E3(2), E4, E5	E3(3), E3(4)	E2	E1
	Gravel/stone/boulder content (v/v %) *	0	1 - 10	11 - 25	26 - 50	> 50
	Electrical conductivity(μs/cm) *	< 300	300 - 600	600 - 1400	1400 - 3500	> 3500
	Susceptibility to sheet/rill erosion *	Very low	Low	Moderate	High	Very high
	Susceptibility to gully erosion *	Very low	Low	Moderate	High	Very high
	Susceptibility to wind erosion *	Very low	Low	Moderate	High	Very high

Land is assessed for agricultural production on the basis of climate, topography and the inherent characteristics of the soil. It is a general assessment that identifies the versatility and potential productivity of an area for a range of crops and pastures. It is assumed that commonly-used management practices will occur, particularly in relation to cultivation and fertiliser application. Supplementary water application is not anticipated. This assessment has been based on cropping, which is a more intensive land use and requires a higher level of management, than grazing.

Note: The potential agricultural productivity of an area can thus be classified by the CTS criteria (Climate, Topography and Soil) e.g. the 'ideal' prime agricultural areas would be denoted by C_1 T_1 S_1 compared with another area that had, for example, a 5 - 7 month growing season, slopes of 3% and a depth to rock/hardpan of only 0.7 m, denoted by C_3T_2 S_4. The overall Land Capability Class of this latter land would be 4; with soil factors being the major limiting features.

* See Appendix A

Table 2.4 Land capability assessment for on-site effluent disposal.

PARAMETERS INFLUENCING EFFLUENT DISPOSAL	LAND CAPABILITY RATINGS				
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Slope (%) *	< 3	3 - 10	11 - 20	21 - 32	> 32
Flooding risk *	Nil	Low	Moderate	High	Very high
Drainage *	Rapidly drained	Well drained	Moderately drained	Imperfectly drained	Poorly/very poorly drained
Depth to seasonal watertable (m)	> 2.0	2.0 - 1.5	1.5 - 1.0	1.0 - 0.5	< 0.5
Depth to hard rock/impermeable layer (m)	> 1.5	1.0 - 1.5	1.0 - 0.75	0.75 - 0.5	< 0.5
Number of months/year when average daily rainfall > Ksat *	0	1	2	3	> 3
Permeability (Ksat mm/day) *	> 500 **	500 - 100	100 - 50	50 - 10	< 10

Note: Areas capable of absorbing effluent from a standard anaerobic, all-waste, septic tank connected to a single family dwelling (approximate output of 1000 litres per day)*** by means of:

i) absorption trenches
ii) transpiration beds *

* See Appendix A

** Permeabilities > 1000 mm/day could pollute groundwater

*** A permeability of 10 mm/day is equivalent to disposing of 1000 litres per day along a 0.5 x 200 m trench

Table 2.5 Land capability assessment for earthen (farm) dams.

PARAMETERS INFLUENCING THE CONSTRUCTION OF EARTHEN DAMS	LAND CAPABILITY RATINGS				
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Slope (%) *	3 - 7	0 - 3	7 - 10	10 - 20	> 20
Linear shrinkage (%) *	0 - 5	6 - 12	13 - 17	18 - 22	> 22
Suitability of subsoil *	Very high	High	Moderate	Low	Very low
Depth to seasonal watertable (m)	> 5	-	5 - 2	-	< 2
Depth to hard rock (m)	> 5	5 - 3	3 - 2	2 - 1	< 1
Permeability (Ksat mm/day) *	< 1	1 - 10	11 - 100	101 - 1000	> 1000
Dispersibility of subsoil (Emerson)	E3(2), E3(3)	E3(1), E3(4)	E2(1), E2(2), E5(A), E5(B)	E2(3), E2(4), E5(C), E5(D)	E1, E6, E7, E8
Susceptibility to slope failure	Very low	Low	Moderate	High	Very high

Note: This table should only be considered for small farm dams to 1000 m^3 in capacity, that have a top water level less than 3 m above the original ground surface at the upstream side of the wall.

Rock outcrop, depth of topsoil and flooding risk were also considered but have not been included for reasons given in Appendix A.

* See Appendix A

Table 2.6 Land capability assessment for secondary roads.

PARAMETERS INFLUENCING SECONDARY ROADS	LAND CAPABILITY RATINGS				
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Slope (%)	0 - 1	2 - 5	6 - 10	11 - 30	> 30
Drainage *	Rapidly	Well	Moderately	Imperfectly	Poorly
Depth of seasonal watertable (m)	> 5	5 - 2	2 - 1	1 - 0.5	< 0.5
Proportion of stones and boulders (v/v %) *	0	1 - 10	11 - 20	21 - 50	> 50
Depth to hard rock (m)	> 1.5	1.5 - 0.75	0.75 - 0.51	0.5 - 0.25	< 0.25
Susceptibility to slope failure *	Very low	Low	Moderate	High	Very high
Linear shrinkage (%) *	< 6	7 - 12	13 - 17	18 - 22	> 22
Bearing capacity (kPa) *	> 50		< 50		
Flooding risk *	Nil	Low	Moderate	High	Very high
Dispersibility of subsoil Emerson (> 4% slope) *	E6, E7, E8	E4, E5, E3(1), E3(2)	E3(3), E3(4)	E2	E1
Unified Soil Group	GW, GC, SC	SM, SW, GM	SP, CL, CH,MH, GP	ML	Pt, OH, OL

Note: Areas capable of being used for the construction of earthen roads for light vehicles without sealed surfaces or concrete drainage and kerbing.

* See Appendix A

Table 2.7 Land capability assessment for building foundations.

PARAMETERS INFLUENCING BUILDING FOUNDATIONS	LAND CAPABILITY RATINGS				
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Slope (%) i) Slab ii) Stumps/footings	 0 - 1 0 - 5	 2 - 5 6 - 10	 6 - 10 11 - 30	 11 - 30 30 - 45	 > 30 > 45
Drainage *	Rapidly drained	Well drained	Moderately well drained	Imperfectly drained	Poorly drained
Depth to seasonal watertable (m)	> 5	5 - 2	2 - 1	1 - 0.5	< 0.5
Proportion of stones and boulders (v/v %)	0	1 - 10	11 - 20	21 - 50	> 50
Depth to hardrock (m)	> 1.5	1.5 - 0.75	0.75 - 0.51	0.5 - 0.25	< 0.25
Susceptibility to slope failure *	Very low	Low	Moderate	High	Very high
Linear shrinkage (%) * i) Slab ii) Stumps/footings	 < 12 < 6	 13 - 17 7 - 12	 18 - 22 13 - 17	 22 - 30 18 - 22	 > 30 > 22
Flood risk	Nil	Low	Moderate	Moderate/high	High

Note: Areas capable of being used for the construction of buildings of one or two stories. It is assumed that any excavation will be less than 1.5 m and can be completed by a tractor-backhoe or equipment of similar capacity. Two methods of construction are considered:

i) Concrete slab - 100 mm thick and reinforced
ii) Stumps or strip footings

* See Appendix A

NB: Pole-construction buildings are more tolerant of slope but less tolerant of linear shrinkage than buildings with stumps or strip footings however other factors become increasingly important, such as erosion risk, susceptibility to slope failure, depth to hard rock and accessibility.

Table 2.8 Land capability assessment for urban and rural residential development.

URBAN RESIDENTIAL (< 0.4 ha)		RURAL RESIDENTIAL (0.4-2.0 ha)	
Building foundations	No change to rating classes	**Building foundations**	No change to rating classes
		Secondary roads	No change to rating classes
		Effluent disposal	**Upgrade by 1 rating class** if major limitation is due to permeability, drainage and depth to hard rock No change to rating class if another criteria is the major limitation present
		Farm dams	No change to rating classes

Urban residential development usually occurs on allotment sizes of 0.4 ha (1 acre) or below. Variation in the physical characteristics of the land and soil are unlikely to occur over small allotments, and where severe physical limitations exist, this will restrict the flexibility in management and design of a chosen development. New residential subdivisions require the provision of town water supply, primary roading and sewage, which often leads to a high level of engineering input and cost to overcome the severe physical constraints of the land. Options for development are therefore restricted by the establishment cost of urban subdivisions, allotment price and demand, rather than the physical limitations of the land. The capability of a map unit to sustain urban residential development will therefore be a good indicator of the establishment costs of a particular subdivision. The urban residential capability assessment is based on the capability of the land to support building foundations.

Rural residential development involves a range of land uses. There is a need to consider the capability of each individual land use in assessing the overall capability of a map unit to sustain rural residential development. More intensive use of the land will require an improved level of management to reduce the likelihood of land degradation.

The land and soil within certain map units can vary substantially within the Shire of Mitchell. This variation within a map unit is more likely to occur as allotment size increases. It is recognised that in allotments greater than 5 ha, land more capable of sustaining various types of land use may be found upon detailed inspection. For example, dam construction may be restricted by shallow soil depth on a small allotment, however on a large allotment a minor drainage line may be found to contain sufficient soil depth to enable a dam to be constructed. However rural residential allotment size varies from 0.4 - 2.0 ha in the Shire of Mitchell, therefore variation in land and soil is expected to be minimal (except where an allotment crosses a map unit boundary). In assessing the capability of land to sustain rural residential development, the capability class for each required land use has been combined to determine an overall class. In the case of rural residential development, the classes have been modified in recognition of the larger allotment size. Greater variation of land and soils within a map unit has been recognised and the ratings have been modified accordingly.

3. LAND MANAGEMENT GUIDELINES

3.1 Management of land characteristics that influence land use

The criteria used in land capability rating tables have been selected because of the limitations they impose on the use of the land. This section explains why these features are important and how an improved level of management can reduce or even overcome the limitation. The information has been extracted from Rowe et al. (1980) and Charmin and Murphy (1991).

3.1.1 Soil texture

Relevant Land Use(s)
Agriculture
Earthen Dams

Soil texture is largely determined by the proportions of different-sized soil particles which make up the soil. Topsoils with well-graded textures have a relatively even distribution of particle sizes from clay through to sand, and tend to be better able to support agricultural and pastoral activities than either very sandy or very clayey soils. They are better able to withstand cultivation and compaction and are more resistant to soil erosion.

Soil texture is closely related to available water-holding capacity. The fine sandy loam - silty clay loam soils have more available water than sands or clays, and so can maintain plant growth for longer periods after wetting. Texture is also an important determinant in soil infiltration and internal drainage, with sandy soils tending to have greater infiltration rates and better internal drainage than loam or clay soils. Clay soils are generally more suitable for grazing than for agriculture. Well-structured or self-mulching clays may be very difficult to cultivate in either the wet or dry states. On the other hand, soils with coarse or sandy texture are very unstable and easily eroded, and may need the protection of a vegetative cover over the dry season.

Some of the limitations imposed by soil texture can be reduced or overcome by special treatments such as the addition of stabilising chemicals and incorporating organic matter.

3.1.2 Boulders and rock outcrop

Relevant Land Use(s)
Agriculture
Secondary Roads
Building Foundations

Boulders and rock outcrop provide physical obstacles to excavation, cultivation and plant growth, and so inhibit land uses involving these activities. It may be possible to remove isolated rock outcrops by blasting, but for extensive uses such as cropping and grazing, boulders and rock outcrop are a permanent limitation. Additional costs may be involved with the increased management required to maintain pasture growth or reduce storm water run-off from rocky areas.

3.1.3 Depth to hard rock

Relevant Land Use(s)
Agriculture
Effluent Disposal
Earthen Dams
Secondary Roads
Building Foundations

The presence of shallow hard rock (< 0.5 m) causes problems for engineering and agricultural land use. Shallow hard rock may need frequent removal for engineering activities such as road works, building foundations and other shallow excavation work. Shallow hard rock may be overcome with heavy machinery and blasting. Agricultural land use including cropping and farm dams are permanently restricted where shallow hard rock is present.

Very shallow soils are inherently more susceptible to erosion and require the protection of a permanent undisturbed cover of vegetation.

3.1.4 Depth of topsoil

Relevant Land Use(s)
Agriculture
Construction

Topsoil is not favoured as a construction material because of its low bearing capacity. The greater the depth of topsoil, the greater the cost of removing and stockpiling it. Many excavation permits now require the topsoil to be re-spread on construction sites to facilitate revegetation and this can be done successfully provided the compacted surface is broken up prior to the topsoil being returned.

A deep topsoil is preferable for agriculture as it is generally the area of maximum biological activity, and is therefore usually the most productive area for plant growth.

Appropriate farming practices such as direct drilling and minimum tillage will retain the organic matter and sustain the amount of biological activity.

3.1.5 Depth to seasonal, perched or permanent watertable

Relevant Land Use(s)
Agriculture
Effluent Disposal
Earthen Dams
Secondary Roads
Building Foundations

The presence of a watertable close to the surface causes problems for both agricultural and engineering land uses. Saturated soils have a low bearing capacity so, for uses dependent on a stable foundation (e.g. building foundations, roads), a high watertable is undesirable.

High watertables restrict the percolation of additional water from rainfall, irrigation or the effluent from septic tanks through the soil profile, whereas a fluctuating watertable is likely to cause leaching of the more mobile plant nutrients, or the concentration of iron compounds which immobilise nutrients such as phosphorus. Poor aeration in the zone of saturation will restrict root growth. Trafficability can be adversely affected, and in the case of effluent disposal, public health aspects may be of concern. High watertables may also restrict the depth of excavation for farm dams and quarries, even shallow excavations for sand and gravel deposits.

Watertables can be lowered by pumping or constructing artificial drains, however if the water is saline, disposal options are limited.

3.1.6 Dispersible clays

Relevant Land Use(s)

Agriculture
Earthen Dams
Secondary Roads

Dispersion is the spontaneous deflocculation of the clay fraction of a soil in water. Slaking is the breakdown of an aggregate into smaller aggregates. Dispersion and slaking are important characteristics of a soil because of their influence on the stability of the soil structure. Soils with a high degree of slaking or dispersion have a high erosion potential and any activity that exposes the topsoil or subsoil to rainfall or running water increases the risk of erosion.

Dispersible topsoils usually have poor physical characteristics, such as surface crusting, cloddiness, poor aeration and low emergence of plant seedlings. Maintenance of an effective pasture cover or litter layer reduces raindrop splash, dispersion and the associated surface sealing of topsoils.

Dispersible subsoils predispose a site to tunnel or gully erosion. The risk may be minimised by careful pasture management such as ensuring that the slopes and drainage depressions are well vegetated with plant species that have deep root systems and high water requirements. Road batters may be subject to slumping and erosion, with subsequent turbidity of run-off water and sedimentation in nearby water storages. As the dispersibility of the subsoil increases, so does the need to reduce batter slopes and establish a protective vegetative cover on the exposed soil.

3.1.7 Flooding

Relevant Land Use(s)

Agriculture
Effluent Disposal
Earthen Dams
Secondary Roads
Building Foundations

Flooding can be a problem on land with very low gradients and within confined drainage ways. Precise data is difficult to obtain on the frequency of flood events and the classes have been determined by observations of land form, catchment geometry and soil types which reflect recent sediment deposition. A distinction should be made between fast flowing flood waters (flash floods) and flooding caused by a rise in water levels with little flow (inundation). The type and severity of impact caused by these two forms of flooding differ and therefore different types of management may be required to reduce the hazard.

Floods are a threat to human safety, causing damage to property and livestock. Thus, flood-prone land should not be used for intensive development, but should be retained for land use such as grazing, where stock can be moved to higher ground in times of increased hazard. In some areas the problem may be overcome by building levee banks or retarding basins, however there may be severe environmental problems caused by this form of management. Some modification of flooding characteristics may be possible by special management aimed at delaying surface run-off. When dealing with large catchments, the problem is a long-term hazard and a permanent limitation.

3.1.8 Organic matter

Relevant Land Use(s)

Agriculture
Earthen Dams
Roads

Where soil materials are to be used as road fill or for earthen dams, the presence of organic matter reduces soil quality for these purposes. Soils containing even moderate amounts of organic matter are more compressible and less stable than inorganic soils. The presence of organic material in sand for concrete is also undesirable.

When used as a medium for plant growth, a high level of organic matter is most desirable as it improves soil structure and chemical fertility. Soils high in organic matter are good for intensive cropping, however cultivation promotes rapid oxidation of organic matter and the condition of the topsoil will deteriorate if the organic matter is not replaced. Organic matter levels can be increased by sowing improved pastures, ploughing in green manure crops, and stubble retention.

3.1.9 Permeability

Relevant Land Use(s)

Agriculture
Effluent Disposal
Earthen Dams

Soils of low permeability have poor drainage through the profile. On sloping land, lateral flow may occur above an impervious layer thereby draining the water away from the site, but on relatively flat areas such soils can become waterlogged and inhibit plant growth or become too boggy for the use of agricultural machinery. Low permeability in soils also reduces the efficiency of effluent disposal systems. This limitation can be overcome if sufficient area is available to increase the length of an absorption trench or utilise plants to transpire water from the effluent disposal area. For earthen dams, low permeability in the floor, the sides and the walls of the dam is most desirable. An extremely permeable soil may have excessive leaching of plant nutrients or an inability to retain moisture for plant growth. Such a soil may drain too rapidly to purify the effluent from septic tanks, thereby increasing the risk of polluting groundwaters or nearby streams.

3.1.10 Plasticity index

Relevant Land Use(s)

Agriculture
Earthen Dams
Secondary Roads

The plasticity index is a measure of the range of moisture content over which the soil is in the plastic state. A soil is most easily worked or is most readily deformed when in the plastic state. A low index indicates that the range is narrow, which is desirable where the stability of the material is important, such as in a road subgrade. However where the soil is to be cultivated, a higher plasticity index is desirable to enable working over a wider range of moisture contents.

3.1.11 Linear shrinkage (shrink-swell potential)

Relevant Land Use(s)

Agriculture
Effluent Disposal
Earthen Dams
Secondary Roads
Building Foundations

This relates to the capacity of clayey soil material to change in volume with changes in moisture content, and is dependant on the quantity and nature of the clay minerals present. The shrink-swell characteristics of a soil influence the capability of land for uses such as roads or buildings which require a stable substrate. Buildings and roads shift or crack in soils which undergo large changes in volume during periodic wetting and drying. Construction on soils with a high shrink-swell potential requires special techniques such as laying deeper-than-usual foundations for roads or using a reinforced concrete slab rather than stumps or strip footings for buildings.

3.1.12 Site drainage

Relevant Land Use(s)

Effluent Disposal
Secondary Roads
Building Foundations

Site drainage is influenced by soil type, soil permeability, steepness of slope, slope shape, rainfall and position in the landscape. For most land uses it is important that water flows freely from the site, since poor site drainage can result in the land becoming waterlogged and boggy, inhibiting plant growth, damaging roads and buildings through subsidence, and reducing the capacity of the area to dispose of effluent. Special works or higher levels of management may be necessary to overcome poor site drainage and this will add to the cost of development and production.

3.1.13 Slope

Relevant Land Use(s)

Agriculture
Effluent Disposal
Earthen Dams
Secondary Roads
Building Foundations

As the angle and length of slope increases so too does the erosion hazard. The loss of adequate ground cover during the construction of dams, roads and buildings, or on land that is cultivated or overgrazed, increases the risk of erosion. Steeper slopes are more difficult and costly to use for agricultural, forestry or road-making activities, and impose limitations on the type of machinery which can be used.

Certain soil types become unstable in wet conditions. As the slope increases, the risk of mass movement also increases, particularly if large quantities of water are contained in the soil profile. Instability can occur on natural slopes, under trees or pasture, road batters and earthen dam banks.

Effluent from septic tanks contains high levels of nutrients and bacterial organisms. If the absorption beds are situated on sloping land, then during wet periods when the soil profile may be saturated (from excessive rainfall and/or run-off from upslope), there is an increased risk of effluent being washed into the streams and water storages further down the catchment. This may result in adverse consequences for water quality and aquatic ecosystems.

3.1.14 Soil reaction

Relevant Land Use(s)

Agriculture

The pH of the soil is a measure of its acidity or alkalinity. Most plants have a pH range in which optimum growth can be expected. Soil acidification occurs as nitrates that were fixed by pasture legumes are leached from the soil, and by the addition of acids in superphosphate. With the long-term use of superphosphate and nitrogen fixing legumes, and the constant removal of grain, hay and/or animal products from the land, the topsoils in many areas have become more acid ($pH < 5.5$ in H_20) and the potential for aluminium toxicity has increased. Acid soils and aluminium toxicity can result in a decline in plant vigour and growth.

3.1.15 Gravel, stones and boulders

Relevant Land Use(s)

Agriculture
Secondary Roads
Building Foundations

The gravel, stone and boulder content in a soil can restrict land use and plant growth in the following ways:

i) reducing the available water supply in the profile; content and nutrient supply in the profile;
ii) increasing the water and tear on cultivating and excavating machinery;
iii) increasing the cost of harvesting root and tuber crops, e.g. potatoes.

Little can be done to overcome this limitation, other than the continual removal of stones from an area as they appear on the land surface

4. DETAILED MAP UNIT DESCRIPTIONS AND LAND CAPABILITY RATINGS

To provide adequate coverage of land resource information for the Shire of Mitchell Council, it has been necessary to collect information at two different scales. This is due to the high cost associated with detailed survey over such a large area.

Detailed land resource information has been collected for areas where there is considerable pressure for more intensive development of rural land (e.g. residential uses); these areas are centred around the major townships of Wallan, Kilmore, Broadford and Seymour. This information has been collected and mapped at a scale of 1:25,000.

In comparison, the rural areas of the Shire have little pressure for more intensive development. Less detailed information has been collected in these areas to support agricultural enterprises, and identify land and water degradation problems. This information has been collected and mapped at a scale of 1:100,000.

At both scales, map units have been differentiated by common geology, landform and soil type. Although at a scale of 1:100,000, the combination of slope classes has resulted in considerably less detail in the accuracy of information collected and mapped. This is immediately obvious when comparing the number of map units which may be identified at the two levels.

1:100,000		**1:25,000**	
Symbol	Slope class	Symbol	Slope class
s)	steep slopes > 32%	a) b)	steep crest > 32% steep slopes > 32%
m)	moderate slopes 11-32%	c) d)	moderate steep slopes 21-32% moderate slopes 11-20%
g)	gentle slopes 1-10%	e) f) g) h)	gentle crests 4-10% gentle slopes 4-10% very gentle slopes 1-3% drainage depression 1-10%
p)	plains < 1%	p)	plains < 1%

This section of the report describes both the 1:100,000 and 1: 25,000 land resource information collected. For each type of geology present in the Shire, there is a general description of the common landforms and soil types, and a discussion of the major limitations to land use. This is followed by a two page description of 1:25,000 scale map units, and a single page description of 1:100,000 scale map units, both formats include the following information:

- general site conditions,
- land degradation,
- soil profile description and analysis.
- land capability assessments.

Please note, both the 1:100 000 and 1:25 000 scale land resource information has been prepared to assist with strategic planning in rural areas. This information is not recommended for use in site specific assessment of planning proposals. Additional site specific information will be required to satisfy this level of planning.

Note:

(i) Many soil types have undergone some level of disturbance during human settlement. These modified soils are now considered to be characteristic of the Shire, while soils in their original condition are relatively rare.

(ii) Soil observation depth did not exceed 1.5m. Therefore depth to hard rock and depth to seasonal watertable have been generalised where they exceed 1.5m.

(iii) pH recorded in the soil profile descriptions are field pH results only. The pH recorded in the interpretation of laboratory analysis (see Appendix C.4.2.) are $CaCl_2$, or field pH as indicated.

(iv) Metamorphic aureoles are found adjoining granitic intrusions throughout the Shire. These aureoles are comprised of metamorphosed Silurian/Devonian and Ordovician sediments. The common soil and landforms of the aureoles are described under the relevant parent material.

(v) Minor drainage lines have not been mapped as separate map units due to limitations of scale, however many of the actual drainage lines are indicated on the base map as part of the hydrology cover.

4.1 QUATERNARY ALLUVIAL MAP UNITS

The alluvial material covers approximately 49 450 hectares of the Shire of Mitchell. Geological age is estimated to be between 100 000 and 1.8 million years.

Soils deposited by major rivers in the Shire, originate from a mixture of geologies and exhibit much variation in soil type. Soil nutrient status depends on the minerals received from the parent material in the catchment. Flood plains may receive a regular deposition of silt size material, rich in nutrients from eroded topsoils, or the less desirable clay material from eroded subsoils that tend to crust on the soil surface or smother existing vegetation. Seasonal waterlogging can limit productivity in floodplain areas. Relic or elevated floodplains are usually well drained. The natural flow of the Goulburn River has been dramatically influenced by the construction of the Eildon Reservoir. The controlled releases of water from the Eildon Reservoir have altered the incidence and degree of flooding, effecting the amount, location and volume of the material deposited upon existing floodplain areas. Sand and gravel mining, desnagging and mechanical activities have altered the hydraulic characteristics of the river. Significant disturbance has occurred on these alluvial areas due to agricultural uses, such as cropping, grazing and irrigated horticulture. Soil compaction, nutrient depletion and the decline in soil structure are common on areas exposed to intensive forms of agriculture. Most soils present are considered to be disturbed soils with frequent mixing of topsoils and subsoils due to cultivation.

Alluvial soils vary considerably depending on their location within the Shire.

Soils common to the elevated terraces of the Goulburn River include massive red and yellow duplex soils. Common surface textures are sandy clay loams over mottled clay subsoils. The mottling of the subsoil indicates poor drainage. Lateral movement of water above the B horizon would be common on this map unit. The profile has a slow permeability rating.

The soils present on floodplains are highly variable. In the upper catchment area of streams, course sandy sediments are more prevalent, with finer sediments being deposited lower in the catchment. For this study, major soil types were identified in the lower catchment where soils show less variation. In general, the soils common to the Goulburn River floodplain are poorly structured red and yellow uniform clays which contain fine sand throughout the profile. The colour variation in the subsoil relates to differences in site drainage.

The common soil type found along the Sunday Creek floodplain is a moderately structured yellow uniform sandy loam. Soil nutrient status is low. The profile is moderately permeable and water storage capacity for plant growth is high.

The soils found along the Darbyminga Creek floodplain are yellow uniform clays. Topsoil structure is commonly weak to moderate, and overlies poorly structured subsoils. Mottles can be found in some profiles depending on specific site drainage.

The alluvial plain of Whiteheads Creek consists of bleached, yellow duplex soils with weak to massive structure. Topsoils are commonly loams overlying subsoils containing light to medium mottled clays.

The alluvial plain of the Wallan area in the south of the Shire, contains uniform, dark grey heavy clay soils. These soils are characterised by seasonal cracking and surface ponding, which indicates high levels of linear shrinkage. The alluvial materials making up this Wallan plain area are predominantly basaltic in origin.

The McIvor Creek alluvial soils are commonly yellow and red duplex soils, with the latter being the minor soil type. Both have poorly structured soil profiles. Textures are commonly clay loam overlying clays with high sand content throughout the solum. Mottles are also present in the subsoil.

Land management considerations

The alluvial map units have the highest quality agricultural land in the district. Although these map units are classed as moderate in capability, existing limitations can be overcome by improving the level of land management. With rural residential development encroaching upon alluvial areas, fragmentation of existing agricultural land is occurring. This will have an impact on the viability of agriculture in the future. The value of these agricultural lands to the district should be considered in future planning decisions.

The major concerns in these units include flooding risk, site drainage, salinity, soil structure decline, stream bank erosion, acidic soils, soils with high levels of linear shrinkage and surface and ground water pollution.

Forty three percent of the total number of soil samples collected on the alluvial map units were acidic. Acidic soils can cause a chemical effect resulting in plant establishment failure, increase in plant disease and poor plant growth. Fertiliser response is restricted and overall productivity is reduced. Stock grazing on such pastures may also be affected.

The highest level of agricultural activity is on the elevated river terraces of the Goulburn River.

Within the alluvial units, there are few areas of salt affected land, however salting has the potential to significantly reduce agricultural production and may cause considerable damage to foundations, plumbing and gardens in residential areas. Where salting occurs in agricultural zones, it will require careful management to minimise loses in production and soil loss through sheet erosion. In residential areas, it may be necessary to consider rezoning options and prohibit further development on land known to be affected by salting. Salting is considered a very high hazard and may require long term remedial action at a catchment wide level, for control to be achieved. Although the incidence of salting in this map unit is low, it is advisable to become familiar with identifying its presence and the associated indicator plants. Bare soils and the presence of spiny rush are good indicators of salinity.

Flooding risk is of greater importance on the lower active floodplains where flood frequency is high and may cause significant problems for site access, effluent disposal and building foundations. The elevated river terraces have a lower flooding frequency and may allow greater development.

Linear shrinkage refers to the degree of shrinkage and swelling of soil. It is dependant on the clay content and the clay mineral types present in the soil, as well as depth of fluctuation in moisture content and the rainfall variations, both short and long term. Many of these areas show a phenomenon known as gilgai formation. This results in various types of surface humps and hollows formed by massive shrinking and swelling of the soils. Gilgai formations are a good indicator of soils with high linear shrinkage. Another indicator is fence posts that may lean in all directions.

Subsoil drainage and permeability is generally slow in soils of high linear shrinkage, and when combined with a high flooding risk poses a high risk for effluent disposal to pollute watercourses.

Soil structure decline is common on these map units. Soil structure grades are commonly stronger on uncultivated areas.

Any form of intensive livestock production accompanied by the presence of high levels of effluent may impact on surface and ground water hydrology.

Gravel extraction from river beds alters water flow, thereby increasing the potential for erosion and pollution, while disrupting the complex ecological systems contained within the river systems.

SOILS OF QUATERNARY ALLUVIAL ORIGIN

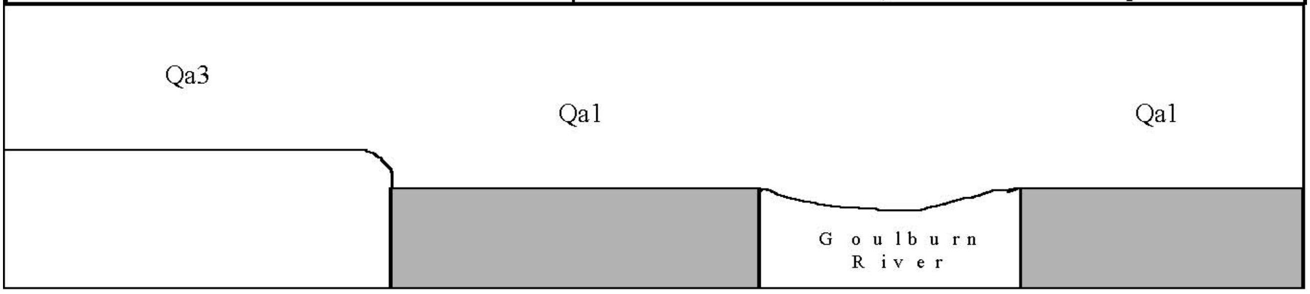
Plate 1 (B11) Map unit Qa2
PPF: Um4
Black Kandosol

Plate 2 (M2) Map unit: Qa3
PPF: Dr2.12
Red Dermosol

Plate 3 (M1) Map unit: Qap2
PPF: Ug5.28
Grey Vertosol

Plate 4 (M3) Map unit: Qap1
PPF: Dy3.41
Yellow Kurosol

MAP UNIT SYMBOL: **Qa1**	MAP UNIT: **Quaternary alluvium, Goulburn River, active floodplain**



A. GENERAL DESCRIPTION

Continual meandering of the Goulburn River has created narrow, low lying floodplains. This active floodplain is not continuous and exists at varying elevations adjacent to the River. Flooding of these low lying floodplains is common. The deep soils associated with these floodplains are characterised by a number of distinct layers which represent different periods of flooding and deposition. There is considerable variation in soil type as elevation has influenced flood frequency, however weakly structured uniform soils are common with fine sand present throughout the profile. Billabongs may be found within this unit.

SITE CHARACTERISTICS

Parent Material Age:	Quaternary	**Depth to Seas. Watertable:**	> 1.5 m
Parent Material Lithology:	Alluvium	**Flooding Risk:**	High
Landform Pattern:	Alluvial plain	**Drainage:**	Well drained
Landform Element:	Channel bench	**Rock Outcrop:**	Nil
Slope a) common:	< 1%	**Depth to Hard Rock:**	> 1.5 m
Slope b) range:	0-3%		
Potential Recharge to Groundwater:	Low		
Major Native Vegetation Species:	River Red Gum		
Present Land Use:	Grazing, irrigated horticulture		
Length of Growing Season	April - October		

LAND DEGRADATION

Degradation Processes	Water Erosion sheet/rill	gully	Wind Erosion	Mass Movement	Salting	Acidification
Susceptibility	Low	Low	Low	Nil	Nil	Low
Incidence	Very low	Very low	Very low	Nil	Nil	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION		Preliminary Survey
1A	0-30 cm	Dark Grey (10YR4/1) light clay with fine sand, weak subangular blocky structure, rough fabric, pH 6.0. Clear transition to:
2A	30-50 cm	Brown (10YR5/3) fine sandy clay loam, massive structure, earthy fabric, pH 6.0. Gradual transition to:
2B	50-70 cm	Greyish brown (10YR5/2) light clay with fine sand, weak subangular blocky structure, rough fabric, pH 6.0.

CLASSIFICATION

Factual Key:	Uf (major) Um (minor)
Australian Soil Classification:	Grey Kandosol, medium, non gravelly, clayey, very deep
Unified Soil Group:	Not available

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH (H_2O)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
1A	6.0	NA	NA	NA	NA	NA	NA	NA	NA
2A	6.0	NA	NA	NA	NA	NA	NA	NA	NA
2B	5.0	NA	NA	NA	NA	NA	NA	NA	NA

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

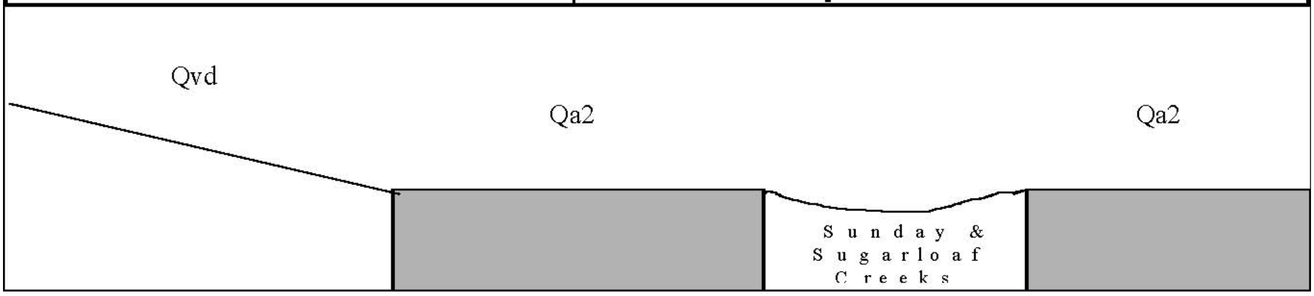
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(estimate)
Available Water Capacity:	Very high	(> 200 mm H_2O)
Linear Shrinkage (B horizon):	Low	(estimate)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_1S_2$	Moderate length of growing season
Effluent Disposal (septic tanks)	5	Very high flooding risk
Farm Dams	3	Moderate depth to seasonal watertable
Building slab **stumps/footings**	5 5	Very high flooding risk Very high flooding risk
Secondary Roads	5	Very high flooding risk
Rural Residential	5	Effluent disposal, building foundations, secondary roads
Urban Residential	5	Flooding risk

MAP UNIT SYMBOL: **Qa2**	MAP UNIT: **Quaternary alluvium, active flood plain**



A. GENERAL DESCRIPTION

Narrow to moderately wide floodplains occur along major creeks such as Sunday, Sugarloaf, McIvor, Darbyminga and Back Creeks within the study area. The deep soils associated with these flood plains are characterised by a number of distinct layers which represent different periods of flooding and deposition. The soils are variable, however uniform dark greyish brown silty loams are common, with fine sand present throughout the profile. Minor soil types include uniform clays and bleached yellow duplex soils. Mottled subsoils are common. The area is prone to flooding and impeded drainage as indicated by the oxidised root channels in the topsoil.

SITE CHARACTERISTICS

Parent Material Age:	Quaternary	**Depth to Seas. Watertable:**	> 1.4 m
Parent Material Lithology:	Alluvium	**Flooding Risk:**	Very high
Landform Pattern:	Floodplain	**Drainage:**	Moderately well drained
Landform Element:	Channel bench	**Rock Outcrop:**	Nil
Slope a) common:	< 1%	**Depth to Hard Rock:**	> 1.4 m
Slope b) range:	0-1%		
Potential Recharge to Groundwater:		Low	
Major Native Vegetation Species:		River Red Gum, Yellow Box, Kangaroo Grass, Wallaby Grass.	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low	Low	Moderate	Very low	Moderate	Moderate
Incidence	Low	Low	Low	Very low	Low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B11 (Appendix D)

1A1	0-5 cm	Dark greyish brown (10YR4/2) silt loam with fine sand, strong granular structure, ped size 2-5 mm, rough fabric, moderately weak consistence, pH 4.5. Abrupt transition to:
1A2	5-20 cm	Brown (10YR5/3) silty loam with fine sand, faint fine pale mottles are common, weak platy structure, peds 20-50 mm, rough fabric, moderately firm consistence, pH 4.6. Clear transition to:
2A	20-30 cm	Very dark grey (10YR3/1) silty loam with fine sand, faint fine pale mottles are common, weak platy structure, peds 10-20 mm, rough fabric, moderately firm consistence, pH 4.7. Gradual transition to:
3A	30-45 cm	Very dark greyish brown (10YR3/2) silty loam with fine sand, faint fine pale mottles are common, weak platy structure, peds 20-50 mm, rough fabric, moderately firm consistence, pH 4.7. Gradual transition to:
4A	45-120 cm	Very dark greyish brown (10YR3/2) silty loam with fine sand, many medium distinct grey and pale mottles, weak platy structure, peds 20-50 mm, rough fabric, pH 5.3. Gradual transition to:
4B	120-140 + cm	Brown (10YR5/3) silty loam with fine sand, many medium distinct orange and pale mottles, weak platy structure, peds 20-50 mm, rough fabric, moderately firm consistence, pH 6.8.

CLASSIFICATION

Factual Key:	Um4 (major) Uf, Dy3.41 (minor)
Australian Soil Classification:	Sodic, Eutrophic, Black Kandosol; thin, non-gravelly, silty/silty, very deep
Unified Soil Group:	ML

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
1A1	4.5**	<1	VL	L	D	S	S	H	L
1A2	4.6	2.0	VL	L	D	S	S	H	L
2A	4.7	<1	VL	L	D	D	S	H	L
3A	4.7	<1	VL	L	D	D	S	M	M
4A	5.3	2.4	VL	L	D	D	S	VL	M
4B	6.8	<1	VL	L	D	D	S	VL	H

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

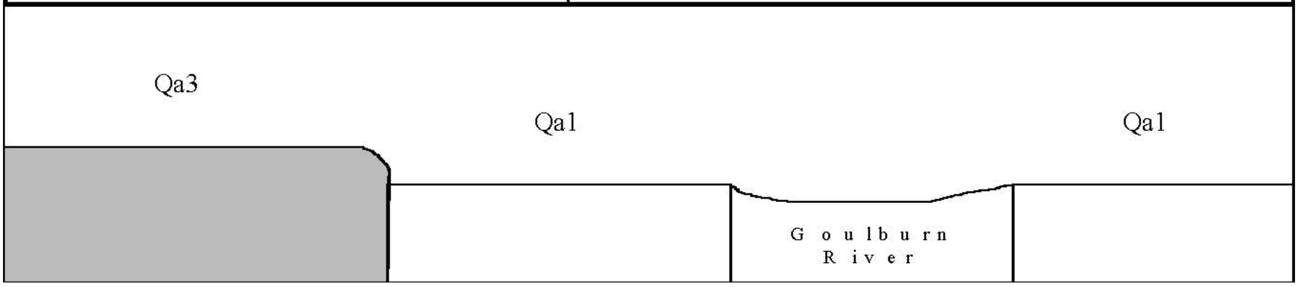
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(average 176 mm/day, range 7-300 mm/day)
Available Water Capacity:	Very high	(285 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(4%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_1S_3$	Moderate length of growing season
Effluent Disposal (septic tanks)	5	Very high flooding risk
Farm Dams	4	High permeability
Building slab **stumps/footings**	5 5	Very high flooding risk Very high flooding risk
Secondary Roads	5	Very high flooding risk
Rural Residential	5	Effluent disposal, building foundations, secondary roads
Urban Residential	5	Flooding risk

MAP UNIT SYMBOL: **Qa3**	MAP UNIT: **Quaternary alluvium, Goulburn River terrace**



A. GENERAL DESCRIPTION

The Goulburn River terraces are relict floodplains which may reach over 1 km in width. These terraces are not continuous and their elevation is such, that flooding would not be expected. Soils vary depending upon the elevation of the terrace. Weakly structured red and yellow duplex soils are common, with fine sand present throughout the profile. These terraces are utilised for irrigated horticulture, grazing and intensive animal husbandry.

SITE CHARACTERISTICS

Parent Material Age:	Quaternary	**Depth to Seas. Watertable:**	> 1.5 m
Parent Material Lithology:	Alluvium	**Flooding Risk:**	Nil
Landform Pattern:	Gentle undulating plain	**Drainage:**	Moderately well drained
Landform Element:	Terrace plain	**Rock Outcrop:**	Nil
Slope		**Depth to Hard Rock:**	> 1.5 m
a) common:	1%		
Slope			
b) range:	0-3%		

Potential Recharge to Groundwater:	Low – Nil
Major Native Vegetation Species:	River Red Gum
Present Land Use:	Cropping (dryland and irrigated), Grazing, Intensive animal husbandry.
Length of Growing Season	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low-mod	Moderate	Low	Low	Low	Low
Incidence	Very low	Very low	Very low	Nil	Nil	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M2 (Appendix D)

A1	0-20 cm	Dark brown (7.5YR3/4) sandy clay loam, weak subangular blocky structure, peds 10-20 mm, rough fabric, pH 5.5. Clear transition to:
B1	20-60 cm	Strong brown (7.5YR4/6) light clay, weak subangular blocky structure, ped size 20-50 mm, rough fabric, pH 6.0. Gradual transition to:
B21	60-85 cm	Reddish brown (5YR4/4) medium clay, many red and orange mottles, moderate subangular blocky structure, ped size 20-50 mm, smooth fabric, pH 7.5. Gradual transition to:
B22	85-110 cm	Dark reddish brown (5YR3/4) medium clay, many red mottles, moderate subangular blocky structure, ped size 20-50 mm, smooth fabric, pH 7.5. Gradual transition to:
B23	110-130 + cm	Reddish brown (5YR4/4) medium clay, massive structure, earthy fabric, pH 8.5.

CLASSIFICATION

Factual Key:	Dr2.11 (major) Dr3.11, Dy3.11, Dy3.41
Australian Soil Classification:	Mesotrophic, Bleached Mottled, Red Dermosol, medium, non gravelly, clay loamy, very deep
Unified Soil Group:	CL

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.5	0	VL	L	S	S	T	H*	VL
B1	4.9	1	VL	L	D	S	S	VL*	L
B21	6.5	1	VL	M	D	S	S	VL*	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

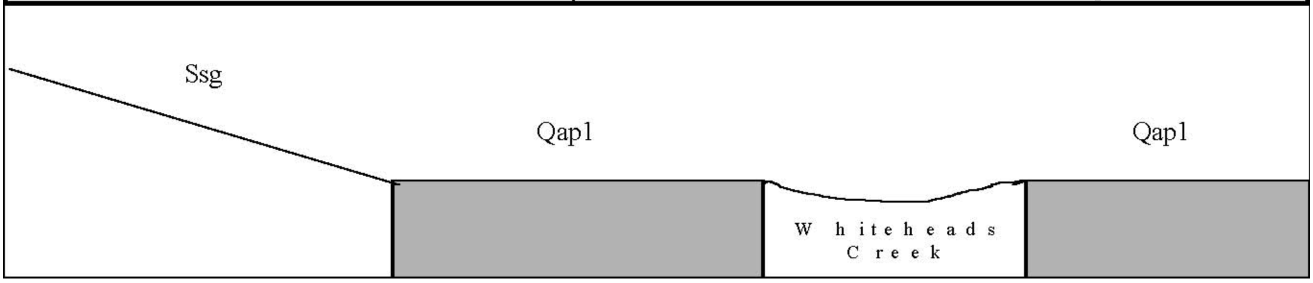
SOIL PROFILE CHARACTERISTICS:

Permeability:	Slow	(average 50 mm/day, range 40-60 mm/day)
Available Water Capacity:	Very high	(265 mm H_2O)
Linear Shrinkage (B horizon):	Low	(10%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_2S_3$	Moderate length of growing season
Effluent Disposal (septic tanks)	4	High permeability
Farm Dams	3	Moderate permeability, moderately dispersible subsoils
Building slab stumps/footings	3 3	Moderately well drained Moderately well drained
Secondary Roads	3	Moderately well drained, Unified Soil Group
Rural Residential	3	Effluent disposal
Urban Residential	3	Drainage

MAP UNIT SYMBOL: **Qap1**	MAP UNIT: **Quaternary alluvium, Whiteheads Creek alluvial plain**



A. GENERAL DESCRIPTION

A broad alluvial plain is associated with Whiteheads Creek. Minor flooding occurs in this unit. The dominant soil type is a weakly structured, bleached yellow duplex soil. Much of these soils have been disturbed through cultivation leading to the mixing of topsoils and subsoils. Salting is common on the alluvial plain. Minor gully erosion also occurs.

SITE CHARACTERISTICS

Parent Material Age:	Quaternary	**Depth to Seas. Watertable:**	> 1.5
Parent Material Lithology:	Alluvium	**Flooding Risk:**	Low
Landform Pattern:	Alluvial plain	**Drainage:**	Imperfectly drained Nil
Landform Element:	Plain	**Rock Outcrop:**	< 1.5m
Slope a) common:	1%	**Depth to Hard Rock:**	
Slope b) range:	0-3%		

Potential Recharge to Groundwater:	Low-moderate
Major Native Vegetation Species:	River Red Gum
Present Land Use:	Grazing, cropping
Length of Growing Season	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low	Mod	High	Low	Moderate	Low
Incidence	Low	Low	Low	Nil	Moderate	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M3 (Appendix D)

A1	0-15 cm	Dark greyish brown (10YR4/2) fine sandy loam, weak subangular blocky structure, ped size 20-50 mm, rough fabric, pH 5.5. Clear transition to:
A2	15-30 cm	Light yellowish brown (10YR6/4), bleached (10YR7/3), fine sandy loam, massive structure, earthy fabric, pH 5.0. Clear transition to:
B1	30-40 cm	Light yellowish brown (10YR6/4) sandy clay loam, many medium size distinct mottles, weak subangular blocky structure, ped size 20-50 mm, rough fabric, pH 5.0. Gradual transition to:
B21	40-70 cm	Light yellowish brown (2.5Y6/3) light medium clay, many coarse pale mottles, strong angular blocky structure, ped size 5-10 mm, smooth and rough fabric, firm consistence, pH 5.5. Clear transition to:
B22	70-80 cm	Light yellowish brown (2.5Y6/3) light clay, many coarse pale mottles, weak polyhedral structure, ped size 10-20 mm, rough fabric, very few rounded medium pebbles, pH 6.5. Clear transition to:
B23	80-105 cm	Brown (10YR5/3) medium clay, many coarse pale mottles, strong angular blocky structure, ped size 5-10 mm, smooth fabric, firm consistence, pH 7.5. Gradual transition to:
B24	105-130 + cm	Greyish brown (2.5Y5/2), light clay, many distinct coarse mottles, weak angular blocky structure, rough fabric, pH 9.5.

CLASSIFICATION

Factual Key: Dy3.41 (major), Dy3.42 (minor)

Australian Soil Classification: Mesotrophic, Bleached, Mottled, Yellow Kurosol medium, non gravelly, loamy, very deep

Unified Soil Group: CL

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.3	0	VL	VL	S	S	T	H*	VL
A2	4.2	0	VL	VL	D	S	T	VL*	VL
B22	4.6	2	VL	L	D	D	T	L*	M

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

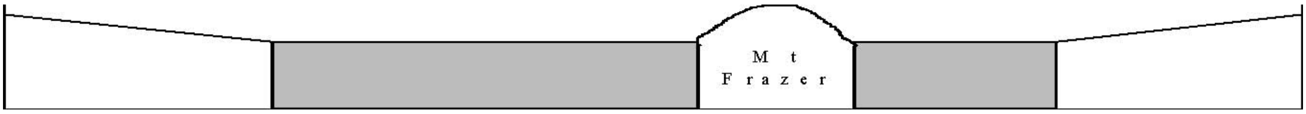
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(average 157 mm/day, range 120 - 175 mm/day)
Available Water Capacity:	Very high	(270 mm H_2O)
Linear Shrinkage (B horizon):	Low	(12%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_2S_3$	Moderate length of growing season, moderate depth of topsoil
Effluent Disposal (septic tanks)	4	Imperfect drainage
Farm Dams	4	High permeability
Building slab **stumps/footings**	4 4	Imperfect drainage Imperfect drainage
Secondary Roads	4	Imperfect drainage
Rural Residential	4	Farm dams, building foundations, secondary roads
Urban Residential	4	Drainage

MAP UNIT SYMBOL: **Qap2**	MAP UNIT: **Quaternary alluvium, Wallan alluvial plain**
Ssg Qap2	Qap2 Ssg Ssg



A. GENERAL DESCRIPTION

The Wallan alluvial plain is composed of mixed sediments from the surrounding sedimentary and basalt terrain which have been deposited during flooding of the Merri Creek. Uniform dark grey heavy clay soils are common. These soils have very high levels of linear shrinkage (18%) leading to seasonal cracking and surface ponding. Special precautions must be taken for engineering purposes in this map unit. For buildings this involves special foundation design, for dams the wall batters must be flatter and the walls must not be allowed to dry out. These soils are easily identified in the field by an uneven soil surface caused by soil movement associated with continual drying and wetting, this uneven soil surface is often referred to as Gilgai formations. Frequent, but minor flooding occurs adjacent to Merri Creek.

SITE CHARACTERISTICS

Parent Material Age: Parent	Quaternary	**Depth to Seas. Watertable:**	surface ponding
Material Lithology:	Alluvium	**Flooding Risk:**	Low
Landform Pattern:	Alluvial plain	**Drainage:**	Poorly drained
Landform Element:	Terrace plain	**Rock Outcrop:**	Nil
Slope		**Depth to Hard Rock:**	> 2.0 m
a) common:	< 1%		
Slope b) range:	< 1%		

Potential Recharge to Groundwater:	Low-Nil
Major Native Vegetation Species:	Nil
Present Land Use:	Grazing
Length of Growing Season	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low	Low	Very Low	Nil	Low	Low
Incidence	Very Low	Nil	Very Low	Nil	Low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M1 (Appendix D)

A1 0-10 cm Dark grey (2.5Y4/1), light medium clay, moderate subangular blocky structure, ped size 10-20 mm, rough fabric, pH 5.5. Gradual transition to:

B21 10-30 cm Dark grey (2.5Y4/1), light medium clay, few fine distinct yellow mottles, weak columnar structure, ped size 100-200 mm, smooth fabric, pH 6.5. Gradual transition to:

B22 30-75 cm Grey (2.5Y5/1), light medium clay, fine distinct yellow mottles are common, moderate lenticular structure, ped size 20-50 mm, smooth fabric, pH 6.5. Diffuse transition to:

B23 75-140 cm Dark grey (2.5Y4/1), medium heavy clay, fine distinct orange mottles are common, moderate lenticular structure, ped size 20-50 mm, smooth fabric, pH 6.5.

CLASSIFICATION

Factual Key: Ug5.28 (major)
Australian Soil Classification: Epipedal, Grey Vertosol, non gravelly, fine, very fine, very deep
Unified Soil Group: CH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.7	NA	VL	H	S	S	T	H*	VL
B21	5.2	6	VL	VH	D	S	S	M-H*	VL
B22	5.5	NA	VL	VH	D	S	S	L*	H
B23	5.8	19	M	VH	D	S	S	L*	H

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

SOIL PROFILE CHARACTERISTICS:

Permeability:	Slow	(average 20 mm/day)
Available Water Capacity:	Very high	(220 mm H_2O)
Linear Shrinkage (B horizon):	High	(18%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_1S_3$	Length of growing season, depth of topsoil, electrical conductivity (B23)
Effluent Disposal (septic tanks)	5	Shallow depth to seasonal watertable, poorly drained
Farm Dams	5	Shallow depth to seasonal watertable
Building slab **stumps/footings**	5 5	Shallow depth to seasonal watertable, poorly drained Shallow depth to seasonal watertable, poorly drained
Secondary Roads	5	Shallow depth to seasonal watertable, poorly drained
Rural Residential	5	Effluent disposal, farm dams, building foundations, secondary roads
Urban Residential	5	Drainage, depth to seasonal water table

4.2 QUATERNARY VOLCANIC MAP UNITS

Quaternary Volcanic soils cover approximately 21 360 hectares of the Shire of Mitchell . Geological age is estimated to be between 100 00 and 1.8 million years. Olivine basalt, with some alkaline derivatives, is the common parent material of the Quaternary volcanic terrain of the Shire.

One of the most extensive of the lava flows originated from a double vent near Springfield. This vent is flanked to the south and west by high hills of Palaeozoic rocks, and by older vents of previous flows. These surrounding high points forced the lava from the vent near Springfield to flow northwards onto and across what was then the Main Divide to Seymour, a narrow flow also moved down Boyds Creek as far as Darraweit Guim. The Boyds Creek valley flow did not displace Boyds Creek to any extent, and subsequent erosion has reduced the flow to a series of small hillcappings and perched terrace-like patches in the slopes immediately east of Boyds Creek and Deep Creek.

Another substantial flow extends from Pretty Sally to north of Kilmore. In some cases, substantial portions of flows have been removed by erosion so that the remnant patches can only be linked tentatively, from topographic evidence. Lava from eruption points just south of the Kilmore township flowed 360 degrees with the majority of the flow going north linking with the flows from Springfield.

Close to the township of Broadford at Round Hill and Prospect Hill, the lava flows were fast and shallow creating undulating rises and low hills.

The youngest flows are those around Mount Fraser; they overlie an older flow, which originated from Bald Hill, just south of Beveridge. The lavas from Mount Fraser are Pleistocene in age, and extend all the way into the Yarra Delta. Some eruption points have no associated volcanic vents, and their existence is postulated solely from topographic evidence.

Two distinct soil types occur on the basalt map units. They are shallow gradational soils, and uniform cracking clays. The gradational soils are usually red in colour, with some brown occurrences. These soils are most commonly associated with volcanic cones, steeper hills and rises. The topsoils are well-structured heavy clay loams, with a strongly structured medium clay subsoil. Nutrient status is moderate to high throughout the profile and permeability is moderate. Uniform black or dark grey cracking clays are common on the very gentle basalt slopes and extensive volcanic plains. Dark grey moderate to strongly structured heavy clay topsoils overlie dark greyish brown moderate to strongly structured clay subsoils. The properties of these clays cause them to shrink and crack upon drying, hence their name 'cracking clays'. When moist, these cracks close resulting in surface ponding of water. These soils have a very high nutrient status throughout the profile and have been cleared substantially for grazing.

A high proportion of surface stone and boulders are common throughout the gently undulating volcanic plain, although some areas may be devoid of this surface stone.

Land management considerations

The major concerns in these units are steep rocky slopes, shallow depth to hard rock, poor site drainage, impermeable subsoils and the physical restraints associated with building on these soils.

High levels of linear shrinkage create problems with construction of earthen dams, secondary roads and building foundations. Soils which shrink and swell sufficiently to cause problems for buildings and roads are termed expansive or reactive soils. The degree of shrink and swell is dependant on the clay content, the clay mineral types present in the soil, depth of fluctuation in moisture content and the rainfall variations, both short and long term. Many of these areas show a phenomenon known as gilgai formation. This results in various types of surface humps and hollows formed by massive shrinking and swelling of the soils. Gilgai formations are a good indicator of soils with high linear shrinkage as are fence posts that lean all directions.

Rock outcrops are common on the steeper basalt terrain. This will cause significant problems with siting of access tracks, building foundations and effluent disposal for housing development. In addition, the high proportion of surface stone on the gentle basalt terrain will have a similar impact on site development.

Due to poor site drainage and impermeable subsoils, the gently undulating basalt plain is unlikely to be suited to septic tanks, other more appropriate forms of effluent disposal may need to be investigated.

Land degradation is limited on the basalt terrain. Minor sheet erosion occurs on the steep to moderate slopes with some gully erosion associated with salting occurring on the drainage lines.

SOILS OF VOLCANIC ORIGIN

Plate 5 (B4) Map units:Qvh, Qvc, Qvd, Qvf
PPF: Gn3.12
Red Ferrosol

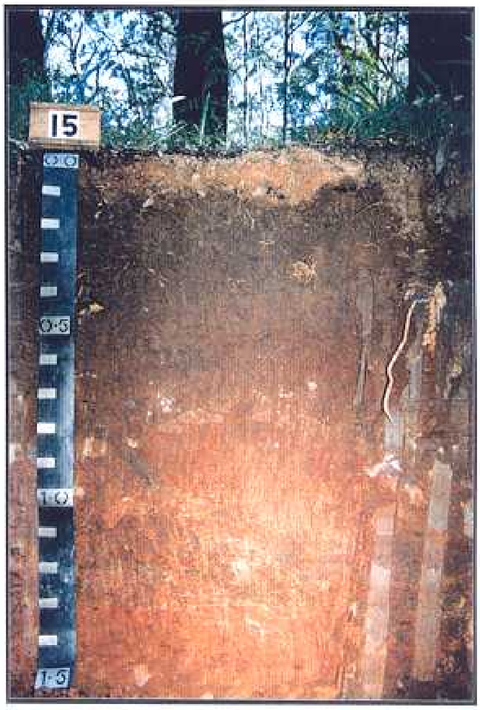
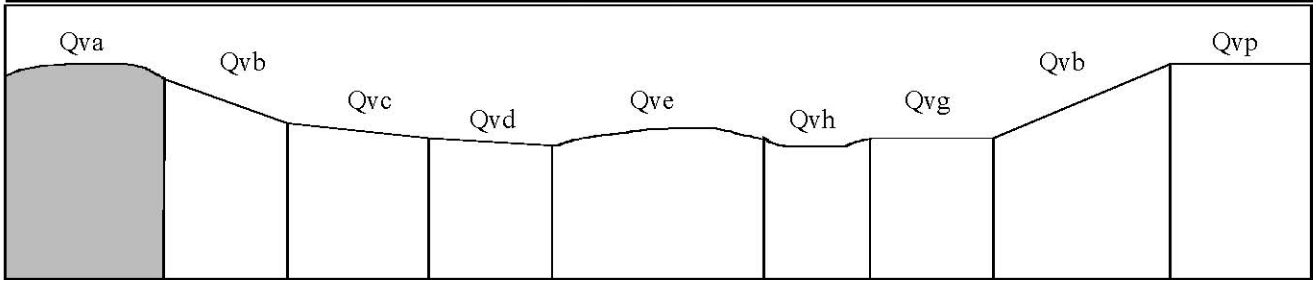


Plate 6 (B1) Map unit: Qvh
PPF: Dy3.13
Grey Sodosol

Plate 7 (B2) Map unit: Qvp
PPF: Ug5.2
Grey Vertosol

MAP UNIT SYMBOL: **Qva**	MAP UNIT: **Quaternary volcanics, steep crest**



A. GENERAL DESCRIPTION

This map unit represents steep crests associated with volcanic cones. The major soil type is a well structured, red gradational soil with a dark reddish-brown clay loam overlying a dark reddish brown light clay subsoil. The soils are shallow and depth to hard rock is less than 70 cm. In very shallow situations (< 20 cm), uniform red clay loams are present. Rock outcrop is very common, and coarse fragments are common throughout the soil profile.

SITE CHARACTERISTICS

Parent Material Age: Parent Material Lithology: basalt **Landform Pattern:** **Landform Element:** **Slope a) common:** **Slope b) range:**	Quaternary Olivine Steep hills/rolling hills Hillcrest 2% 0-2%	**Depth to Seas. Watertable:** **Flooding Risk:** **Drainage:** **Rock Outcrop:** **Depth to Hard Rock:**	> 0.7 m Nil Well drained 0-50% 0.1-0.7 m
Potential Recharge to Groundwater: **Major Native Vegetation Species:** **Present Land Use:** **Length of Growing Season**		Moderate River Red Gum, Yellow Gum Grazing April - October	

LAND DEGRADATION

Degradation Processes	Water Erosion sheet/rill	gully	Wind Erosion	Mass Movement	Salting	Acidification
Susceptibility	Moderate	Very low	Moderate	Very low	Very low	Moderate
Incidence	Low-mod	Very low	Low-mod	Very low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B4 (Appendix D)

A1	0-20 cm	Dark reddish-brown (5YR3/3) heavy clay loam, strong subangular blocky structure, peds 2-5 mm, rough fabric, moderately firm consistence, a few fine basaltic gravel fragments, moderate organic matter content, pH 4.7. Gradual transition to:
B2	20-50 cm	Dark reddish-brown (5YR3/4) medium clay, strong subangular blocky structure, peds 2-5 mm, smooth fabric, moderately weak consistence, a few fine basaltic gravel fragments, pH 5.5 Clear transition to:
BC	50-60 cm	Brown (7.5YR5/4) fine sandy clay loam, common red and grey mottles, moderate subangular blocky structure, peds 5-10 mm, smooth fabric, moderately firm consistence, abundant coarse basaltic gravel fragments, pH 6.5. Gradual transition to:
R	60 cm	Rock (basalt)

CLASSIFICATION

Factual Key:	Gn3.12/3 (major), Gn4.42, Um6 (minor)
Australian Soil Classification:	Haplic, Eutrophic, Red Ferrosol; medium, slightly gravelly, silty/clayey, moderate.
Unified Soil Group:	MH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	5.3	4.8	VL	M	D	D	S	H	L
B2	6.2	27.5	VL	H	D	D	S	M	L
BC	7.5	33.1	VL	H	D	D	S	L	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

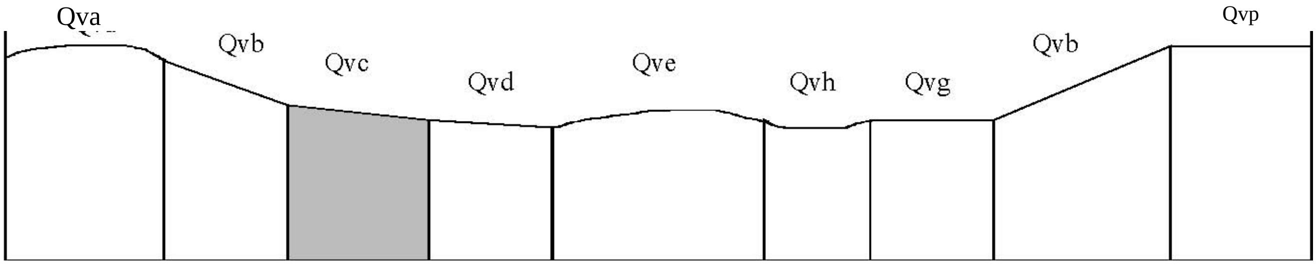
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(average 268 mm/day, range 88-500 mm/day)
Available Water Capacity:	Low	(95 mm H_2O)
Linear Shrinkage (B horizon):	Moderate	(17%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_4S_4$	Shallow depth to hard rock, low available water capacity, high gravel/stone/boulder content
Effluent Disposal (septic tanks)	5	Steep slopes, shallow depth to hard rock
Farm Dams	5	Very low suitability of subsoil, steep slopes, very shallow depth to hard rock
Building slab **stumps/footings**	5 4	Shallow depth to hard rock Shallow depth to hard rock, high proportion of stones and boulders
Secondary Roads	5	Steep slopes
Rural Residential	5	Farm dams, effluent disposal, building foundations, secondary roads
Urban Residential	4	Slope, high proportion of stones and boulders

MAP UNIT SYMBOL: **Qvc**	MAP UNIT: **Quaternary volcanics, moderately steep slope**



A. GENERAL DESCRIPTION

Moderately steep upper slopes occur below both the volcanic cones and elevated volcanic plains. The associated soils are very similar to those occurring on the crests. The soil depth is variable (from 10 cm to 70 cm) with dark reddish-brown clay loam topsoils grading into reddish brown light to medium clay subsoils. These overlie either solid rock, yellow/brown light-medium clay or yellow/brown clay loam subsoils. Where the soils are very shallow, the clay loam topsoil may overlie rock only. Coarse fragments are present throughout the profile and rock outcrops are common. The soils are well structured and moderately permeable. This unit is very susceptible to sheet erosion and mass movement.

SITE CHARACTERISTICS

Parent Material Age: Parent	Quaternary	**Depth to Seas. Watertable:**	> 0.7m
Material Lithology:	Olivine basalt	**Flooding Risk:**	Nil
Landform Pattern:	Rolling/low hills	**Drainage:**	Rapidly drained
Landform Element:	Hillslopes	**Rock Outcrop:**	0-20%
Slope a) common:	22%	**Depth to Hard Rock:**	0.1-0.7 m
Slope b) range:	21-32%		
Potential Recharge to Groundwater:		Moderate	
Major Native Vegetation Species:		River Red Gum	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Very high	Low	Moderate	Moderate	Very Low	Moderate
Incidence	Moderate	Very low	Low	Moderate	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B4 (Appendix D)

A1	0-20 cm	Dark reddish-brown (5YR3/3) heavy clay loam, strong subangular blocky structure, peds 2-5 mm, rough fabric, moderately firm consistence, a few fine basaltic gravel fragments, moderate organic matter content, pH 4.7. Gradual transition to:
B2	20-50 cm	Dark reddish-brown (5YR3/4) medium clay, strong subangular blocky structure, peds 2-5 mm, smooth fabric, moderately weak consistence, a few fine basaltic gravel fragments, pH 5.5 Clear transition to:
BC	50-60 cm	Brown (7.5YR5/4) fine sandy clay loam, common red and grey mottles, moderate subangular blocky structure, peds 5-10 mm, smooth fabric, moderately firm consistence, abundant coarse basaltic gravel fragments, pH 6.5. Gradual transition to:
R	60 cm	Rock (basalt)

CLASSIFICATION

Factual Key: Gn3.12/3 (major), Gn4.1/4.2, Um6 (minor)

Australian Soil Classification: Haplic, Eutrophic, Red Ferrosol; medium, slightly gravelly, silty/clayey, moderate

Unified Soil Group: MH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.7	4.8	VL	M	D	D	S	H	L
B2	5.5	27.5	VL	H	D	D	S	M	L
BC	6.5	33.1	VL	H	D	D	S	L	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

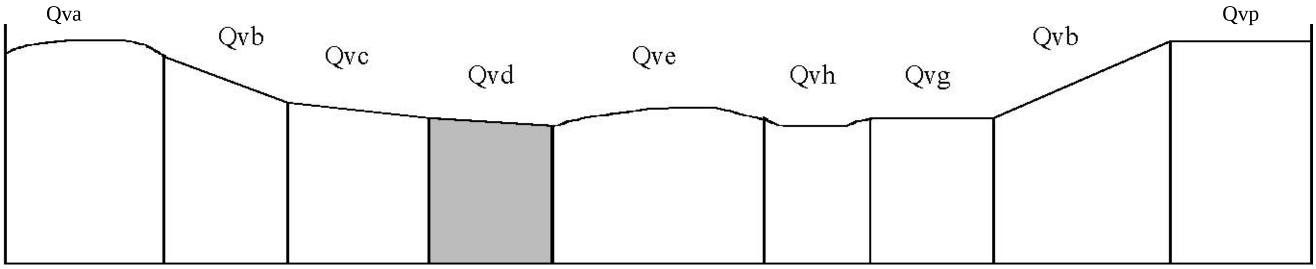
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(average 270 mm/day, range 90-500 mm/day)
Available Water Capacity:	Low	(95 mm H_2O)
Linear Shrinkage (B horizon):	Moderate	(17%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_4S_4$	Moderately steep slope, shallow depth to hard rock
Effluent Disposal (septic tanks)	4	Moderately steep slope, shallow depth to hard rock
Farm Dams	5	Steep slope, very low suitability of subsoil, very shallow depth to hard rock
Building slab **stumps/footings**	4 4	Shallow depth to hard rock, proportion of stones and boulders, steep slope Shallow depth to hard rock
Secondary Roads	4	Moderately steep slope
Rural Residential	5	Farm dams
Urban Residential	4	Slope, high proportion of stones and boulders

MAP UNIT SYMBOL: **Qvd**	MAP UNIT: **Quaternary volcanics, moderate slope**



A. GENERAL DESCRIPTION

These moderate slopes are associated with volcanic cones or the edges of the elevated volcanic plains. The soils are very similar to those occurring on the crests and steeper slopes of the cones (Qva and Qvc) described previously. The soil depth is variable with dark reddish-brown clay loam topsoils grading into reddish brown light to medium clay subsoils. These overlie a deeper horizon of partially weathered rock, hard rock, yellow/brown light-medium clay or yellow/brown clay loam subsoils. In some locations, the colour of the topsoil may be darker (very dark grey top soils). Coarse fragments are present throughout the profile. The soils are well structured and moderately permeable. This unit is very susceptible to sheet erosion and moderately susceptible to mass movement.

SITE CHARACTERISTICS

Parent Material Age: Parent	Quaternary	**Depth to Seas. Watertable:**	> 1.0 m
Material Lithology:	Olivine basalt	**Flooding Risk:**	Nil
Landform Pattern:	Undulating low hills/ rolling hills	**Drainage:**	Rapidly drained
Landform Element:	Mid slope	**Rock Outcrop:**	0-10%
Slope a) common:	15%	**Depth to Hard Rock:**	0.3-1.0 m
Slope b) range:	11-20%		
Potential Recharge to Groundwater:		Moderate	
Major Native Vegetation Species:		River Red Gum, Blackwood	
Present Land Use:		Grazing	
Length of Growing Season:		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Very high	Low	Moderate	Moderate	Very low	Moderate
Incidence	Moderate	Low	Low	Moderate	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B4 (Appendix D)

A	0-20 cm	Dark reddish-brown (5YR3/3) heavy clay loam, strong subangular blocky structure, peds 2-5 mm, rough fabric, moderately firm consistence, a few fine basalt gravel fragments, pH 4.7. Gradual transition to:
B2	20-60 cm	Dark reddish-brown (5YR3/4) medium clay, strong subangular blocky structure, peds 2-5 mm, smooth fabric, moderately weak consistence, common basalt gravel fragments, pH 5.5. Clear transition to:
BC	60-100 cm	Brown (7.5YR5/4) fine sandy clay loam, common medium sized distinct red and grey mottles, moderate subangular blocky structure, peds 5-10 mm, smooth fabric, moderately firm consistence, abundant coarse basalt fragments, pH 6.5. Gradual transition to:
R	100 + cm	Rock (basalt)

CLASSIFICATION

Factual Key:	Gn3.12/3 (major), Gn4.1/42, Um6 (minor)
Australian Soil Classification:	Haplic, Eutrophic Red Ferrosol; medium, slightly gravelly, silty/clayey, moderate
Unified Soil Group:	MH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.7	4.8	VL	M	D	D	S	H	L
B2	5.5	27.5	VL	H	D	D	S	M	L
BC	6.5	33.1	VL	H	D	D	S	L	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

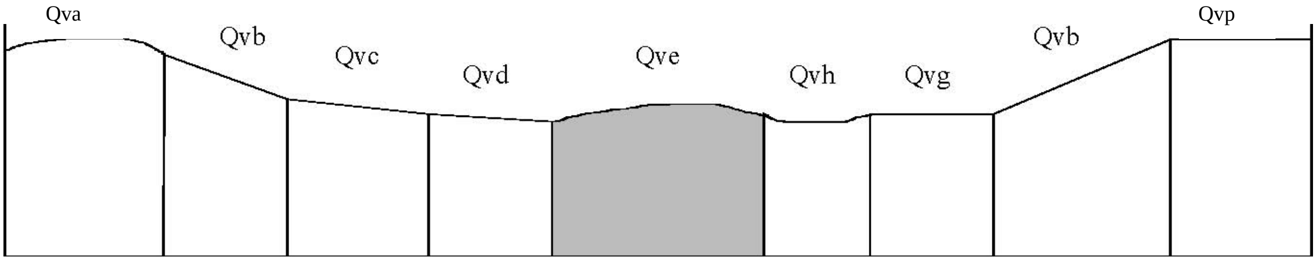
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(average 270 mm/day, range 88-500 mm/day)
Available Water Capacity:	Low	(95 mm H_2O)
Linear Shrinkage (B horizon):	Moderate	(17%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_4S_4$	Shallow depth to hard rock
Effluent Disposal (septic tanks)	4	Shallow depth to hard rock, moderately steep slope
Farm Dams	5	Very low suitability of subsoil, very shallow depth to hard rock
Building slab stumps/footings	4 3	Moderately steep slope Moderate slope, moderate susceptibility to slope failure, linear shrinkage
Secondary Roads	4	Moderately steep slope
Rural Residential	5	Farm dams
Urban Residential	3	Slope, high proportion of stones and boulders, susceptibility to slope failure, linear shrinkage (ii)

MAP UNIT SYMBOL: **Qve**	MAP UNIT: **Quaternary volcanics, gentle crest**



A. GENERAL DESCRIPTION

This map unit represents gentle crests found within gently undulating volcanic plains. The red gradational soils present are shallow to moderate in depth, with dark reddish-brown clay loams overlying dark reddish brown light clay subsoils. Weathered rock, hard rock or sedimentary clays may underlie these soils.

SITE CHARACTERISTICS

Parent Material Age:: Parent	Quaternary	**Depth to Seas. Watertable**	> 0.8 m
Material Lithology: basalt	Olivine	**Flooding Risk:**	Nil
Landform Pattern:	Lava plain	**Drainage:**	Well drained
Landform Element:	Hillcrest	**Rock Outcrop:**	0-30%
Slope a) common:	2%	**Depth to Hard Rock:**	0.3-0.8 m
Slope b) range:	0-2%		

Potential Recharge to Groundwater:	Moderate
Major Native Vegetation Species:	River Red Gum, Yellow Gum
Present Land Use:	Grazing
Length of Growing Season:	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Moderate	Very low	Moderate	Very low	Very low	Moderate
Incidence	Low-mod	Very low	Low-mod	Very low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B4 (Appendix D)

A1	0-20 cm	Dark reddish-brown (5YR3/3) heavy clay loam, strong subangular blocky structure, peds 2-5 mm, rough fabric, moderately firm consistence, a few fine basaltic gravel fragments, moderate organic matter content, pH 4.7. Gradual transition to:
B2	20-50 cm	Dark reddish-brown (5YR3/4) medium clay, strong subangular blocky structure, peds 2-5 mm, smooth fabric, moderately weak consistence, a few fine basaltic gravel fragments, pH 5.5 Clear transition to:
BC	50-80 cm	Brown (7.5YR5/4) fine sandy clay loam, common red and grey mottles, moderate subangular blocky structure, peds 5-10 mm, smooth fabric, moderately firm consistence, abundant coarse basaltic gravel fragments, pH 6.5. Gradual transition to:
C	80 cm	Rock (basalt)

CLASSIFICATION

Factual Key:	Gn3.12/3 (major), Gn4.42, Um6 (minor)
Australian Soil Classification:	Haplic, Eutrophic, Red Ferrosol; medium, slightly gravelly, silty/clayey, moderate.
Unified Soil Group:	MH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	5.3	4.8	VL	M	D	D	S	H	L
B2	6.2	27.5	VL	H	D	D	S	M	L
BC	7.5	33.1	VL	H	D	D	S	L	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

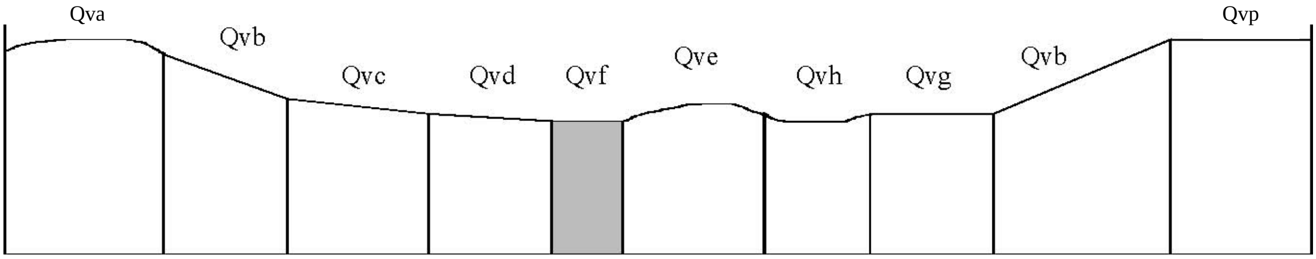
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(average 268 mm/day, range 88-500 mm/day)
Available Water Capacity:	Low	(95 mm H_2O)
Linear Shrinkage (B horizon):	Moderate	(17%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_1S_4$	Shallow depth to hard rock, low available water capacity
Effluent Disposal (septic tanks)	4	Shallow depth to hard rock.
Farm Dams	5	Very low suitability of subsoil, very shallow depth to hard rock.
Building slab **stumps/footings**	3 3	Moderate depth to hard rock, proportion of stones and boulders Moderate depth to hard rock, proportion of stones and boulders, linear shrinkage
Secondary Roads	3	Moderate proportion of stones and boulders, depth to hard rock, Unified Soil Group.
Rural Residential	5	Farm dams
Urban Residential	3	High proportion of stones and boulders, depth to hard rock, linear shrinkage (ii)

MAP UNIT SYMBOL: **Qvf**	MAP UNIT: **Quaternary volcanic, gentle slope**



A. GENERAL DESCRIPTION

Gentle volcanic slopes occur within the undulating volcanic plain or at the base of volcanic cones. The soils are similar to map units previously described, red gradational with dark reddish brown clay loam topsoils and dark reddish brown light to medium clay subsoils, although in this map unit a dark brown gradational soil is also common. There are minor occurrences of cracking clays. Coarse fragments are present throughout the profile and some mottling occurs in the subsoils. Rock outcrop is variable, and is absent in some areas. This unit is susceptible to sheet erosion.

SITE CHARACTERISTICS

Parent Material Age:	Quaternary	**Depth to Seas. Watertable:**	> 1.0 m
Parent Material Lithology:	Olivine basalt	**Flooding Risk:**	Nil
Landform Pattern:	Gently undulating rises/low hills	**Drainage:**	Well drained
Landform Element:	Mid-slope	**Rock Outcrop:**	Nil
Slope a) common:	9%	**Depth to Hard Rock:**	0.5-1.0 m
Slope b) range:	4-10%		

Potential Recharge to Groundwater:	Low-moderate
Major Native Vegetation Species:	River Red Gum, Blackwood
Present Land Use:	Grazing
Length of Growing Season	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	High	Low	Moderate	Low	Very low	Moderate
Incidence	Low	Low	Low	Low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B4 (Appendix D)

A1	0-20 cm	Dark reddish-brown (5YR3/3) heavy clay loam, strong subangular blocky structure, peds 2-5 mm, rough fabric, moderately firm consistence, a few fine basalt gravel fragments, pH 4.7. Gradual transition to:
B2	20-60 cm	Dark reddish-brown (5YR3/4) medium clay, strong subangular blocky structure, peds 2-5 mm, smooth fabric, moderately weak consistence, common basalt gravel fragments, pH 5.5. clear transition to:
BC	60-100 cm	Brown (7.5YR5/4) fine sandy clay loam, common medium sized distinct red and grey mottles, moderate subangular blocky structure, peds 5-10 mm, smooth fabric, moderately firm consistence, abundant coarse basalt fragments, pH 6.5. Gradual transition to:
R	100 + cm	Rock (basalt)

CLASSIFICATION

Factual Key:	Gn3.12/3 (major), Gn4.1/42, Uf6, Ug5.2, Ug6.1 (minor)
Australian Soil Classification:	Haplic, Eutrophic, Red Ferrosol; medium, slightly gravelly, silty/clayey, moderate
Unified Soil Group:	MH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.7	4.8	VL	M	D	D	S	H	L
B2	5.5	27.5	VL	H	D	D	S	M	L
BC	6.5	33.1	VL	H	D	D	S	L	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

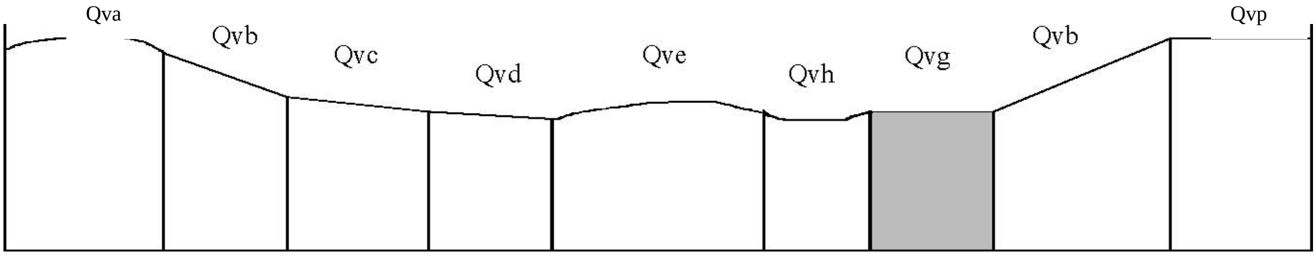
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(average 270 mm/day, range 90-500 mm/day)
Available Water Capacity:	Moderate	(95-142 mm H_2O)
Linear Shrinkage (B horizon):	Moderate	(17%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_3S_3$	Moderate length of growing season, moderate depth to hard rock, low available water capacity
Effluent Disposal (septic tanks)	3	Moderate depth to hard rock
Farm Dams	5	Very low suitability of subsoil, very shallow depth to hard rock
Building slab **stumps/footings**	3 3	Moderate slopes Moderate slopes
Secondary Roads	3	Moderate slope, moderate linear shrinkage, Unified Soil Group
Rural residential	5	Farm dams
Urban residential	3	Slope (i), high proportion of stones and boulders, linear shrinkage (ii)

MAP UNIT SYMBOL: **Qvg**	MAP UNIT: **Quaternary volcanic, very gentle slope**



A. GENERAL DESCRIPTION

Black and dark grey cracking clay soils are common on the very gentle slopes of the volcanic plains. These soils are uniform in nature with self mulching clay topsoils and very dark greyish brown heavy clay subsoils. The soils develop large cracks when dry, hence the name 'cracking clay'. The subsoil contains many distinct orange mottles indicating restricted drainage. Minor soil types present include red and dark brown gradational soils. Occasionally the uniform clays will have a lighter clay loam topsoil. During winter, surface ponding of water is common. A high proportion of surface stone is common in this unit.

SITE CHARACTERISTICS

Parent Material Age:	Quaternary	**Depth to Seas. Watertable:**	> 1.0 m
Parent Material Lithology:	Olivine basalt	**Flooding Risk:**	Nil
Landform Pattern:	Lava plain	**Drainage:**	Poorly drained
Landform Element:	Hillslope	**Rock Outcrop:**	Nil
Slope a) common:	1%	**Depth to Hard Rock:**	0.5-1.0 m
Slope b) range:	0-3%		
Potential Recharge to Groundwater:		Low	
Major Native Vegetation Species:		River Red Gum	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	Water Erosion sheet/rill	Water Erosion gully	Wind Erosion	Mass Movement	Salting	Acidification
Susceptibility	Moderate	Very low	Moderate	Very low	Very low	Very low
Incidence	Low	Very low	Low	Very low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B2 (Appendix D)

A11	0-10 cm	Self mulching, very dark grey (10YR3/2) medium clay, moderate subangular blocky structure, peds 10-20 mm, rough fabric, high organic matter content, pH 4.9. Clear transition to:
A12	10-15 cm	Very dark grey (10YR4/1) medium heavy clay, moderate to strong subangular blocky structure, peds 20-50 mm, smooth fabric, a few basalt fragments, high organic matter content, pH 4.8. Clear transition to:
B21	15-45 cm	Very dark greyish-brown (10YR4/2) heavy clay, weak subangular blocky structure, peds 20-50 mm, smooth fabric, a few basalt fragments, pH 5.2. Clear transition to:
B22	45-70 cm	Very dark greyish brown (10YR4/2) heavy clay, weak subangular blocky structure, peds 20-50 mm , smooth fabric, common basalt fragments, pH 5.7. Clear transition to:
B23	70-75 cm	Greyish brown (10YR5/2) heavy clay, many medium sized distinct orange mottles, weak subangular blocky structure, peds 20-50 mm , smooth fabric, common coarse basalt fragments, pH 6.5.
R	75 cm	Rock (basalt)

CLASSIFICATION

Factual Key:	Ug5.2 (major), Ug6.1, Gn 3.41/42, Um6.41 (minor)
Australian Soil Classification:	Haplic, Self Mulching, Dark Grey Vertosol; gravelly, medium, fine, very fine, moderate.
Unified Soil Group:	CH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A11	4.9	20.9	VL	VH	S	S	S	H	L
A12	4.8	12.5	VL	VH	S	D	S	H	L
B21	5.2	27.4	VL	VH	D	D	S	M	L
B22	5.7	30.3	VL	VH	D	D	S	H	L
B23	6.5	41.0	VL	VH	D	D	S	L	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

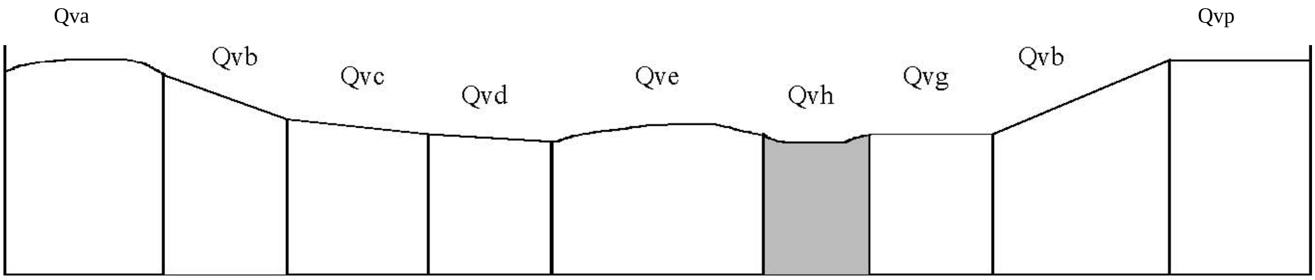
SOIL PROFILE CHARACTERISTICS:

Permeability:	Very slow	(average 6 mm/day, range 2-10 mm/day)
Available Water Capacity:	Low	(68 mm H_2O)
Linear Shrinkage (B horizon):	High	(19%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_2S_4$	Shallow depth to hard rock, low available water capacity, high proportion of stones and boulders
Effluent Disposal (septic tanks)	5	Very low permeability, poorly drained
Farm Dams	5	Very shallow depth to hard rock
Building slab **stumps/footings**	5 5	Poorly drained Poorly drained
Secondary Roads	5	Poorly drained
Rural Residential	5	Farm dams, building foundations, secondary roads
Urban Residential	5	Drainage

MAP UNIT SYMBOL: **Qvh**	MAP UNIT: **Quaternary volcanics, drainage depression**



A. GENERAL DESCRIPTION

The volcanic plains have few drainage depressions. Broad, gentle depressions are common where the volcanic plain is gently undulating, however steeper drainage depressions will occur along the perimeter of elevated volcanic plains. The soils associated with drainage depressions on the basalt plains are generally moderately deep duplex soils with black clay loam topsoils and brown heavy clay subsoils. Mottles are common in the subsoils indicating impeded drainage. Minor soil variations include a cracking brown gradational soil on the edge of drainage depressions where drainage is slightly improved, and uniform cracking clays similar to those that occur on the very gentle slopes.

SITE CHARACTERISTICS

Parent Material Age: Parent	Quaternary	**Depth to Seas. Watertable:**	> 1.0 m
Material Lithology:	Olivine basalt	**Flooding Risk:**	Low
Landform Pattern:	Gently undulating rises/ low hills	**Drainage:**	Imperfectly drained
Landform Element:	Drainage depression	**Rock Outcrop:**	Nil
Slope a) common:	6%	**Depth to Hard Rock:**	> 1.5 m
Slope b) range:	3-15%		
Potential Recharge to Groundwater:		Low	
Major Native Vegetation Species:		River Red Gum	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	Water Erosion sheet/rill	gully	Wind Erosion	Mass Movement	Salting	Acidification
Susceptibility	Moderate	Moderate	Moderate	Low	Low	Low
Incidence	Low	Very low	Very Low	Very low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B1 (Appendix D)

A11	0-25 cm	Black (10YR2.5/1) light clay, strong subangular blocky structure, peds 2-5mm, rough fabric, high organic matter content, pH 4.6. Clear transition to:
A12	25-50 cm	Dark greyish brown (10YR4/2) clay loam with silt, weak to moderate subangular blocky structure, peds 10-20mm, rough fabric, pH 5.2. Gradual transition to:
B21	50-70 cm	Dark greyish brown (10YR4/2) medium-heavy clay, many fine distinct orange and red mottles, weak to moderate subangular blocky structure, 2-5mm, rough fabric, pH 7.4. Clear transition to:
B22	70-100 cm	Brown (10YR5/3) heavy clay, many orange, grey and red mottles, weak subangular blocky structure, peds 5-10mm, rough fabric, a few basalt fragments, pH 6.0. Clear transition to:
B23	100-140 cm	Yellowish brown (10YR5/4) medium-heavy clay, many brown, red and orange mottles, moderate subangular blocky structure, peds 10-20mm, rough fabric, a few basalt fragments, pH 7.6. Clear transition to:

B3 140-145 + cm Brown (7.5YR5/4) light clay, yellow and orange mottles are common, moderate subangular blocky structure, peds 5-10mm, rough fabric, moderately firm consistence, pH 7.8.

CLASSIFICATION

Factual Key:	Dy3.13 (major), Gn 3.4/92 , Ug6.2 (minor)
Australian Soil Classification:	Eutrophic, Mottled-Mesonatric, Grey Sodosol; thick, non-gravelly, silty/clayey, deep
Unified Soil Group:	CH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A11	4.6	< 1	VL	M	D	D	S	H	M
A12	5.2	< 1	VL	L	D	D	S	L	M
B21	7.4	< 1	VL	M	D	D	S	L	H
B22	6.0	4.6	VL	M	D	D	S	L	H
B23	7.6	2.5	VL	M	D	D	S	VL	VH
B3	7.8	1.5	VL	M	D	D	S	VL	VH

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

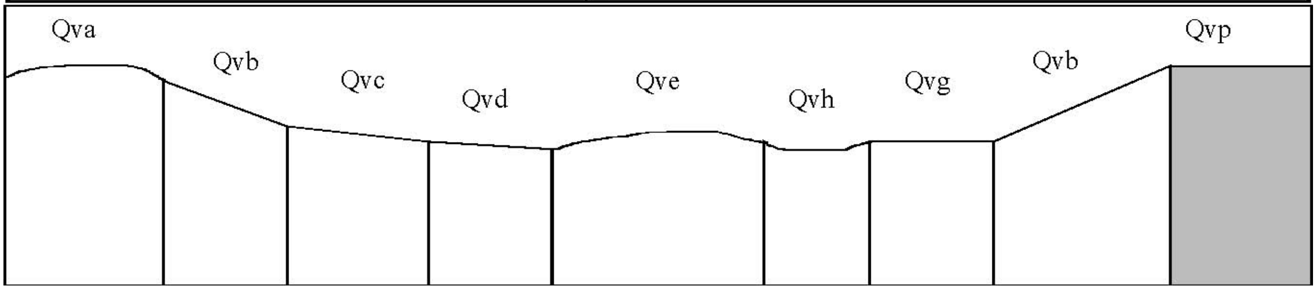
SOIL PROFILE CHARACTERISTICS:

Permeability:	Slow	(average 34mm/day, range 7-62 mm/day)
Available Water Capacity:	Very high	(222 mm H_2O)
Linear Shrinkage (B horizon):	Moderate	(13%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_3S_3$	Moderate slope, length of growing season, depth to hard rock, dispersibility of the topsoil
Effluent Disposal (septic tanks)	4	Imperfect drainage, low permeability
Farm Dams	4	Highly dispersible subsoil
Building slab **stumps/footings**	4 4	Imperfect drainage Imperfect drainage
Secondary Roads	4	Imperfect drainage, highly dispersible subsoil
Rural Residential	4	Farm dams, building foundations, secondary roads
Urban Residential	4	Drainage

MAP UNIT SYMBOL: **Qvp**	MAP UNIT: **Quaternary volcanic, plain**



A. GENERAL DESCRIPTION

Black and dark grey cracking clay soils are common on the volcanic plains. These plains may be elevated above the surrounding landscape depending upon the source of the lava flow. The soils are uniform in nature with self mulching clay topsoils and very dark greyish brown heavy clay subsoils. The soils crack when dry and have surface ponding during winter months. The subsoil contains many distinct orange mottles indicating restricted drainage. Minor soil types present include red and dark brown gradational soils. Occasionally the uniform clays will have a lighter clay loam topsoil. A high proportion of surface stone is common.

SITE CHARACTERISTICS

Parent Material Age: Parent Material Lithology:	Quaternary Olivine basalt	**Depth to Seas. Watertable:**	> 1.0 m
Landform Pattern:	Lava plain	**Flooding Risk:**	Nil
Landform Element:	Plain	**Drainage:**	Poorly drained
Slope a) common:	< 1%	**Rock Outcrop:**	Nil
Slope b) range:	0-1%	**Depth to Hard Rock:**	0.5-1.0 m

Potential Recharge to Groundwater:	Low
Major Native Vegetation Species:	River Red Gum
Present Land Use:	Grazing
Length of Growing Season	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Moderate	Very low	Moderate	Very low	Very low	Very low
Incidence	Low	Very low	Low	Very low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B2 (Appendix D)

A11 0-10 cm Self mulching, very dark grey (10YR3/2) medium clay, moderate subangular blocky structure, peds 10-20 mm, rough fabric, high organic matter content, pH 4.9. Clear transition to:

A12 10-15 cm Very dark grey (10YR4/1) medium-heavy clay, moderate to strong subangular blocky structure, peds 20-50 mm, smooth fabric, a few basalt fragments, high organic matter content, pH 4.8. Clear transition to:

B21 15-45 cm Very dark greyish-brown (10YR4/2) heavy clay, weak subangular blocky structure, peds 20-50 mm, smooth fabric, a few basalt fragments, pH 5.2. Clear transition to:

B22 45-70 cm Very dark greyish brown (10YR4/2) heavy clay, weak subangular blocky structure, peds 20-50 mm , smooth fabric, common basalt fragments, pH 5.7. Clear transition to:

B23 70-75 cm Greyish brown (10YR5/2) heavy clay, many medium sized distinct orange mottles, weak subangular blocky structure, peds 20-50 mm , smooth fabric, common coarse basalt fragments, pH 6.5.

R 75 cm Rock (basalt)

CLASSIFICATION

Factual Key:	Ug5.2 (major), Ug6.1, Gn 3/4, 1/42, Um6.41 (minor)
Australian Soil Classification:	Haplic, Self Mulching, Dark Grey Vertosol; gravelly, medium, fine, very fine, moderate.
Unified Soil Group:	CH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A11	4.9	20.9	VL	VH	S	S	S	H	L
A12	4.8	12.5	VL	VH	S	D	S	H	L
B21	5.2	27.4	VL	VH	D	D	S	M	L
B22	5.7	30.3	VL	VH	D	D	S	H	L
B23	6.5	41.0	VL	VH	D	D	S	L	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

SOIL PROFILE CHARACTERISTICS:

Permeability:	Very slow	(average 6 mm/day, range 2-10 mm/day)
Available Water Capacity:	Low	(68 mm H_2O)
Linear Shrinkage (B horizon):	High	(19%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_1S_4$	Shallow depth to hard rock, low available water capacity, high proportion of stones and boulders
Effluent Disposal (septic tanks)	5	Very low permeability, poorly drained
Farm Dams	5	Very shallow depth to hard rock
Building slab stumps/footings	5 5	Poorly drained Poorly drained
Secondary Roads	5	Poorly drained
Rural Residential	5	Farm dams, building foundations, secondary roads
Urban Residential	5	Drainage

4.3 TERTIARY ALLUVIAL SEDIMENTARY MAP UNITS

Tertiary alluvial sediments cover approximately 260 hectares of the Shire of Mitchell . Geological age is estimated to be between 1.8 and 5 million years.

Tertiary gravel and sand deposits occupy a very small section of the study area. Located in the vicinity of Mangalore and Seymour, the coarse gravels consist of quartz and are often cemented into a dense hard pan by silica and iron oxide. The majority of these Tertiary gravel deposits are remnant hill top deposits which have survived the continued process of erosion. These deposits have been extensively strip mined throughout the district. Extractive processes are still active on some deposits. Areas in which strip mining has occurred will require site inspection to determine varying site conditions.

The soils present in undisturbed areas are poorly structured red gradational soils with sandy clay loams overlying very gravelly clays. Soil depth is generally shallow. Occasional drainage depressions contain similar soils; soil profiles have many rounded large quartz pebbles. Conglomerate (cemented rounded gravels) often underlie subsoils. Underlying gravel layers have been measured to a depth of ten meters.

Some of the alluvial sand and gravel deposits are suitable for processing into concrete aggregates and those deposits, commonly known as ‘Mangalore Gravels’, are best suited to road base and select fill applications.

Soil erosion is not considered to be a major problem where groundcover exists, however disturbed surface soils resulting from strip mining are susceptible to sheet and gully erosion.

The nutrient level of these gravel deposits is extremely low.

Land management consideration

The high proportion of stones and boulders and high permeability are the major constraints to land use.

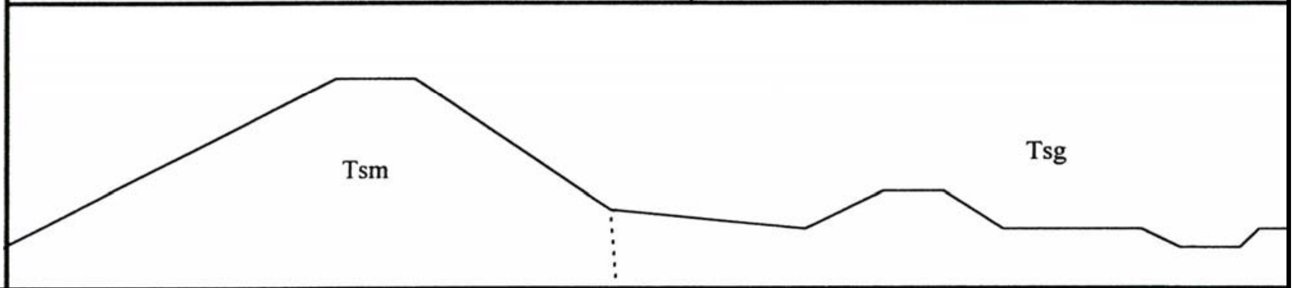
Siting of effluent disposal fields will require special consideration due to the proximity to the Goulburn River, while dam construction will be limited due to poor suitability of subsoil. Alternative effluent disposal systems may be required.

Improved land management is required to protect drought prone hill crests from overgrazing.

Disturbed surface soils resulting from strip mining are susceptible to sheet and gully erosion. Revegetation of disturbed areas is advised to prevent soil degradation.

Due to the small size of these Tertiary deposits, areas containing indigenous flora and fauna should be considered to have very high conservation significance. This should be taken into account when considering planning decisions.

MAP UNIT SYMBOL: **Ts**	MAP UNIT: **Tertiary alluvial Sediments**



Map unit	Tsm	Tsg	
Landform element	Moderately steep slopes	Gentle crest and slopes	Drainage depression
Slope range	11-32%	0-10%	1-10%
Parent material	Tertiary river deposits- gravels, sands and clays		
Site drainage	Well drained	Well drained	Moderately well drained
Dominant Vegetation	Grey box, Red box, Red stringybark	Grey box, Red box, Red stringybark	Grey box, River red gum
Factual Key	Dr 2.11(major) Gn4.51, Dy 3.11 (minor)	Dr 2.11(major) Gn4.51, Dy 3.11 (minor)	Dy 3.11 (major) Dy 3.41 (minor)
Description of common soil type	**A1** 0-10 cm stony reddish brown sandy loam, pH 6.0 **B21** 10-45 cm stony reddish brown sandy clay loam, pH 6.0 **B22** 45-100 cm stony dark reddish grey sandy clay, pH 6.0 **Gravels** 100 cm +	**A1** 0-10 cm stony, reddish brown sandy loam, pH 6.0 **B21** 10-45 cm stony, reddish brown sandy clay loam, pH 6.0 **B22** 45-100 cm stony, dark reddish grey sandy clay, pH 6.0 **Gravels** 100 cm +	**A1** 0-10 cm stony, reddish brown sandy loam, pH 6.0 **B1** 10-45 cm stony reddish brown sandy clay loam, pH 6.0 **B2** 45 cm + mottled, yellowish brown medium clay
Permeability	Very high	Very High	Low
Rock outcrop	Nil	Nil	Nil
Depth to hardrock	> 5 m	> 5 m	> 2 m
Available water capacity	Low	Low	Low
Unified Soil Group	Not available	Not available	Not available
Land Degradation-susceptibility	Sheet & rill - Moderate Gully - Moderate Wind - Very low Slope failure - Low	Sheet & rill - Low Gully - Low Wind - Very low Slope failure - Very low	Sheet & rill - Low Gully - Low Wind - Very low Slope failure - Low
Land Degradation-incidence	Sheet & rill - Moderate Gully - Very low Wind - Very low Slope failure - Nil	Sheet & rill - Very low Gully - Very low Wind - Very low Slope failure - Nil	Sheet & rill - Low Gully - Low Wind - Very low Slope failure - Nil
Land Use	Gravel extraction, grazing	Gravel extraction, grazing	Gravel extraction, grazing
Capability for Agriculture/ major limiting features	Class 4 low available water capacity, high proportion of gravel stone and boulders	Class 4 moderately steep slopes, low available water capacity, high proportion of gravel stone and boulders	Class 4 high proportion of gravel stone and boulders

4.4 DEVONIAN GRANITIC MAP UNITS

Devonian granitic soils cover approximately 50 160 hectares of the Shire of Mitchell. Geological age is estimated to be between 367 and 416 million years. The granitic terrain is diverse, with elevated undulating plateaus, very steep to gentle slopes, broad drainage lines and rock outcrops on the crests, mid and upper slopes. Granitic terrain occurs at Pyalong and Mt Disappointment, both granitic intrusions have resulted in the metamorphosis, folding and uplift of adjacent Ordovician and Silurian/Devonian sediments.

The soils common to the Devonian Granitic map units are derived from both Granite and Granodiorite parent materials. The minerals are the same in both rocks however granodiorite has rather less quartz than granite and contains up to 25 percent of biotite and hornblende.

The elevated granitic plateau of Mt Disappointment contains rounded crests typically covered in tors, gentle slopes and minor drainage lines. Soils present upon crests and upper slopes are commonly shallow uniform sands with a distinctive deep weathered horizon overlying hard rock. Deeper yellow duplex soils occur where soil depth increases in the drainage lines and moderate and gentle slopes. A red gradational soil is also common on gentle slopes in high rainfall areas.

At the edge of the plateau, rocky crests, steep and moderate rocky slopes also contain shallow uniform sands. On many steep slopes, erosion has removed the shallow dark topsoil.

Further east at Pyalong, a gentle undulating plain and steep hills mark the granite terrain. Similar coarse uniform sands and yellow duplex soils occur where soil depth is shallow. Bleached yellow duplex soils are common on the gentle slopes of the plain.

Sandy granitic topsoils are prone to leaching of nutrients and sheet erosion by water and wind. The loss of groundcover through drought or overgrazing often results in extreme soil loss during intense summer rainfalls. This has had the effect of reducing accessibility to some areas as well as reducing moisture availability through excessive drainage.

Much of the area is used for grazing on native and introduced pastures. The more accessible areas are occasionally cropped or sown to introduced pasture species.

The high proportion of rock outcrop, permeable soils and loss of tree cover in the granitic terrain has a major impact on local and regional groundwater recharge. Additional groundwater recharge has contributed to an increase in the incidence of salt

affected land. Examples of this can be seen in the north of the study area where total removal of native vegetation is common.
Salting also occurs in isolated drainage depressions where springs and dams result in restricted drainage and waterlogging.

Land use in the granitic terrain was previously restricted to grazing and minor cropping, however the aesthetic value of this land makes it popular for rural residential development.

Land management considerations
Strong development guidelines are required in the granitic areas due to the high number of physical limitations confronting future rural residential development. Steep slopes, shallow depth to hard rock, dispersible and impermeable subsoils, and significant sheet and gully erosion are important limitations in the granitic units.

Soils of granitic origin are exceptionally prone to erosion. Any activity that removes the surface vegetation and exposes the soil to the erosive elements of wind and water may create very serious land degradation problems. All development on steep granitic terrain will require measures to minimise sheet erosion during construction. Follow up monitoring of sand extraction sites is also advisable as some contractors have been negligent in their obligations to rehabilitate extraction sites.

The shallow depth to hard rock, dispersible subsoils and steep slopes make siting of access roads extremely difficult. In most cases, roads may require surfacing with bitumen, while table drains and culverts will need regular maintenance.

Allotment size for rural residential development will also require careful consideration as shallow soils and rock outcrop will restrict suitable sites for housing and effluent disposal. Soil conservation measures during and following site construction will be required to minimise erosion.

Dam failure is common due to the erosion of dam banks associated with sandy topsoils and dispersive subsoils. Difficulty in locating dam sites may also occur in areas with shallow depth to hard rock. Careful site selection and construction techniques are necessary to avoid dam failure.

Improved management of steep slopes and drought prone crests is required to ensure minimal land degradation in grazing areas.

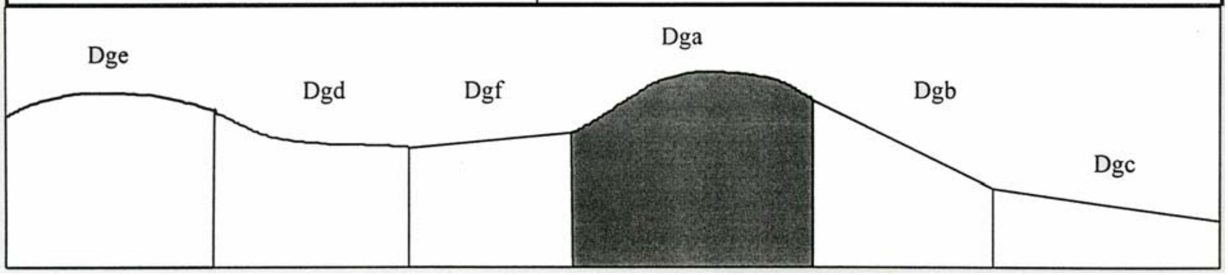
Revegetation of disturbed surfaces and recharge areas should be a priority when considering placing conditions on town planning permits.

SOILS OF DEVONIAN GRANITIC ORIGIN

Plate 8 (B17) Map units: Dga, Dgb, Dge
PPF: Uc2.12
Leptic Tenosol

Plate 9 (B18) Map units: Dge, Dgd, Dgf
PPF: Dy3.42
Grey Sodosol

MAP UNIT SYMBOL: **Dga**	MAP UNIT: **Devonian granitic, steep crest, ridge**



A. GENERAL DESCRIPTION

These crests are usually found at the highest elevations within the granitic landscape. Outcropping granite boulders are generally a common feature of this map unit and the common soils are shallow uniform sandy loams, although depth varies considerably. Very dark brown sandy loams overlie bleached sandy loams. These soils are highly susceptible to wind erosion, particularly under dry conditions, and their nutrient status is low.

SITE CHARACTERISTICS

Parent Material Age: **Parent Material Lithology:** **Landform Pattern:** **Landform Element:** **Slope a) common:** **Slope b) range:**	Devonian Granite/granodiorite Steep/rolling hills Crest 8% 0-35%	**Depth to Seas. Watertable:** **Flooding Risk:** **Drainage:** **Rock Outcrop:** **Depth to Hard Rock:**	> 1.0 m Nil Rapidly drained 0-80% 0.2-1.0m
Potential Recharge to Groundwater: **Major Native Vegetation Species:** **Present Land Use:** **Length of Growing Season**		Very high Blue Gum, Grey Box, Blackwood, Black Wattle, Bracken Grazing April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Moderate	Low	High	Very low	Very low	Low
Incidence	Low	Very low	Low-Mod	Very low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B17 (Appendix D)

A1 0-10 cm Very dark greyish brown (10YR3/2) sandy loam, moderate subangular blocky structure, peds 5-10mm, rough fabric, very weak consistence, many fine granitic gravel fragments, high organic matter, pH 4.5. Clear transition to:

A21 10-20 cm Dark brown (10YR4/3) sandy loam, bleached (10YR7/3) when dry, weak subangular blocky structure, peds 10-20mm, rough fabric, moderately firm consistence, many fine granitic gravel fragments, pH 4.7. Gradual transition to:

A22 20-60 cm Dark brown (10YR4/3) sandy loam, bleached when dry (10YR7/3), apedal, sandy fabric, very strong consistence, many fine granitic gravel fragments, pH 4.5. Clear transition to:

C 60 cm Partially weathered granitic rock

CLASSIFICATION

Factual Key:	Uc 2.21
Australian Soil Classification:	Ochric, Paralithic, Bleached-Leptic Tenosol; thick, gravelly, sandy/loamy, moderate.
Unified Soil Group:	SC

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.5**	13.6	VL	L	D	S	S	VH	L
A21	4.7	13.9	VL	VL	D	S	T	L	L
A22	4.5**	9.9	VL	L	D	S	T	M	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

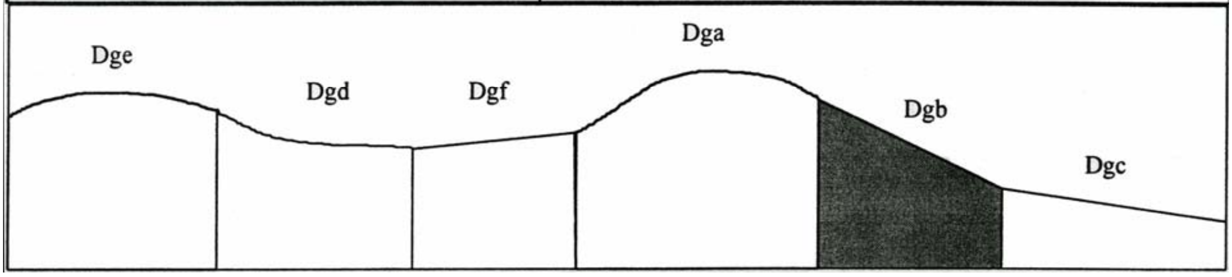
SOIL PROFILE CHARACTERISTICS:

Permeability:	Rapid	(average 1480, range 610-2,440 mm/day)
Available Water Capacity:	Low	(83 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(2%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_1S_4$	Shallow depth to hard rock, low available water capacity, highly susceptible to wind erosion
Effluent Disposal(septic tanks)	5	Very shallow depth to hard rock/impermeable layer, rapid permeability - risk of groundwater or stream pollution
Farm Dams	5	Steep slope, very low suitability of subsoil, very shallow depth to hard rock, high permeability
Building slab **stumps/footings**	5 5	Shallow depth to hard rock Shallow depth to hard rock
Secondary Roads	5	Shallow depth to hard rock
Rural Residential	5	Effluent disposal, farm dams, building foundations, secondary roads
Urban Residential	5	Slope, high proportion of stones and boulders, depth to hard rock

MAP UNIT SYMBOL: **Dgb**	MAP UNIT: **Devonian granitic, steep slope**



A. GENERAL DESCRIPTION

This map unit consist of steep granitic slopes generally with outcropping granite boulders and shallow uniform sandy loam soils. These soils are very susceptible to sheet erosion and highly susceptible to wind erosion and mass movement.

SITE CHARACTERISTICS

Parent Material Age: Parent Material Lithology: **Landform Pattern:** **Landform Element:** **Slope a) common:** **Slope b) range:**	Devonian Granite/granodiorite Steep/rolling hills Crest 35% 0-65%	**Depth to Seas. Watertable:** **Flooding Risk:** **Drainage:** **Rock Outcrop:** **Depth to Hard Rock:**	> 1.0 m Nil Rapidly drained 0-50% 0.2-1.0 m
Potential Recharge to Groundwater: **Major Native Vegetation Species:** **Present Land Use:** **Length of Growing Season**		Very high Blue Gum, Grey Box, Blackwood, Black Wattle, Bracken Grazing April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Moderate	Low	High	Very low	Very low	Low
Incidence	Moderate	Very low	Low - Mod	Very low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B17 (Appendix D)

A1 0-10 cm Very dark greyish brown (10YR3/2) sandy loam, moderate subangular blocky structure, peds 5-10mm, rough fabric, very weak consistence, many fine granitic gravel fragments, high organic matter, pH 4.5. Clear transition to:

A21 10-20 cm Dark brown (10YR4/3) sandy loam, bleached (10YR7/3) when dry, weak subangular blocky structure, peds 10-20mm, rough fabric, moderately firm consistence, many fine granitic gravel fragments, pH 4.7. Gradual transition to:

A22 20-60 cm Dark brown (10YR4/3) sandy loam, bleached when dry (10YR7/3), apedal, sandy fabric, very strong consistence, many fine granitic gravel fragments, pH 4.5. Clear transition to:

C 60 cm Partially weathered granitic rock

CLASSIFICATION

Factual Key:	Uc 2.21
Australian Soil Classification:	Ochric, Paralithic, Bleached-Leptic Tenosol; thick, gravelly, sandy/loamy, moderate.
Unified Soil Group:	SC

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.5**	13.6	VL	L	D	S	S	VH	L
A21	4.7	13.9	VL	VL	D	S	T	L	L
A22	4.5**	9.9	VL	L	D	S	T	M	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

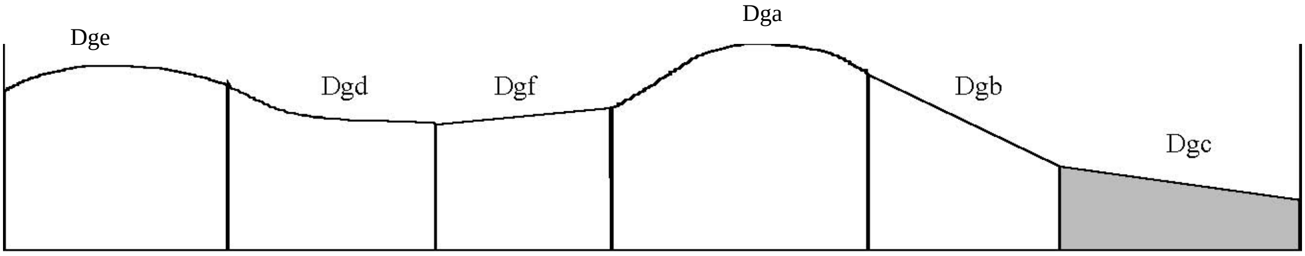
SOIL PROFILE CHARACTERISTICS:

Permeability:	Rapid	(average 1480, range 610-2,440 mm/day)
Available Water Capacity:	Low	(83 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(2%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_5S_5$	Steep slopes, very shallow depth to hard rock, gravel stone and boulder content
Effluent Disposal(septic tanks)	5	Very shallow depth to hard rock/impermeable layer, rapid permeability - risk of groundwater or stream pollution
Farm Dams	5	Very low suitability of subsoil, very shallow depth to hard rock, high permeability
Building slab stumps/footings	5 5	Steep slope, very shallow depth to hard rock, proportion of stones and boulders Very shallow depth to hard rock
Secondary Roads	5	Very shallow depth to hard rock
Rural Residential	5	Effluent disposal, farm dams, building foundations, secondary roads
Urban Residential	5	Slope, high proportion of stones and boulders, depth to hard rock

MAP UNIT SYMBOL: **Dgc**	MAP UNIT: **Devonian granitic, moderately steep slope**



A. GENERAL DESCRIPTION

The moderately steep slopes of the granitic landscape have a mixture of two soil types; bleached yellow duplex soils and uniform sandy loams. The yellow duplex soils are predominant where soil depth increases while the uniform loams are associated with rock outcrop or shallow soils. In the yellow duplex profile, bleached clayey sands overlie a heavily mottled sandy clay loam. These features indicate impeded drainage. This map unit is very susceptible to sheet erosion and highly susceptible to mass movement.

SITE CHARACTERISTICS

Parent Material Age:	Devonian	**Depth to Seas. Watertable:**	> 1.5 m
Parent Material Lithology:	Granite/granodiorite	**Flooding Risk:**	Nil
Landform Pattern:	Steep/rolling hills	**Drainage:**	Moderately well drained
Landform Element:	Hillslope	**Rock Outcrop:**	0-25%
Slope a) common:	26%	**Depth to Hard Rock:**	0.7-1.5 m
Slope b) range:	21-32%		
Potential Recharge to Groundwater:		Low-Moderate	
Major Native Vegetation Species:		Blue Gum	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Very high	Moderate	Moderate	High	Low	Low
Incidence	Moderate	Low - Mod	Low	Low - Mod	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B18 (Appendix D)

A1 0-15 cm Very dark grey (10YR3/1) light sandy clay loam, weak subangular blocky structure, peds 5-10mm, rough fabric, moderately weak consistence, high organic matter, pH 4.4. Clear transition to:

A21 15-25 cm Greyish brown (10YR5/2) clayey sand, bleached (10YR7/3) when dry, apedal, sandy fabric, moderately weak consistence, common fine quartz gravels, pH 4.7. Clear transition to:

A22 25-40 cm Pale brown (10YR6/3) clayey sand, bleached (10YR8/3) when dry, a few medium sized faint orange mottles, apedal, sandy fabric, loose consistence, a few fine quartz gravels, pH 4.9. Clear transition to;

B2 40-120 cm Grey (10YR5/1) sandy clay loam, abundant medium sized distinct orange mottles, weak subangular blocky structure, peds 50-100mm, rough fabric, moderately firm consistence, common fine quartz and feldspar gravels, pH 5.5. Gradual transition to:

B3 120-140 + cm Brown (10YR5/3) sandy loam, abundant fine distinct orange mottles, apedal, sandy fabric, many fine quartz, feldspar and mica gravel fragments, pH 6.6.

CLASSIFICATION

Factual Key:	Dy3.42 (major) Uc2.21 (minor)
Australian Soil Classification:	Eutrophic, Mottled-Subnatric, Grey Sodosol; medium, non-gravelly, loamy/clay loamy, deep.
Unified Soil Group:	CL

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.4**	1.9	VL	L	D	D	S	H	L
A21	4.7	1.3	VL	VL	D	D	S	VL	L
A22	4.9	2.5	VL	VL	D	D	S	VL	H
B2	5.5	2.0	VL	L	D	D	S	VL	H
B3	6.6	7.4	VL	L	D	D	S	VL	M

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

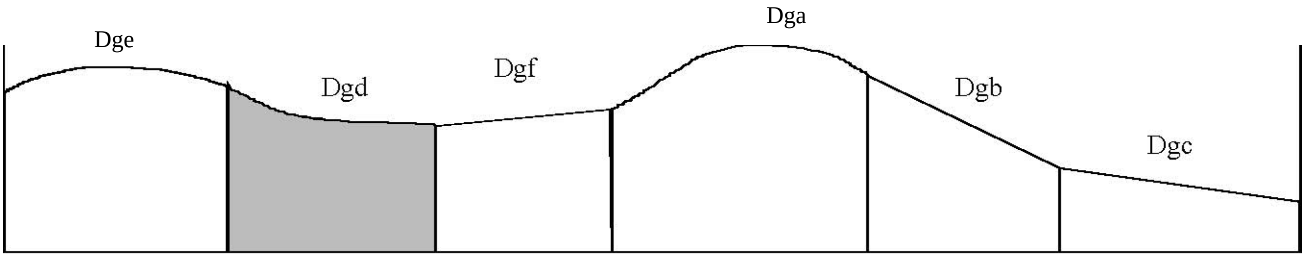
SOIL PROFILE CHARACTERISTICS:

Permeability:	Slow	(average 45 mm/day, range 20-70 mm/day)
Available Water Capacity:	Very high	(224 mm H_2O)
Linear Shrinkage (B horizon):	Low	(9%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_4S_4$	Moderately steep slope
Effluent Disposal (septic tanks)	4	Moderately steep slopes, low permeability
Farm Dams	5	Steep slope
Building slab **stumps/footings**	5 4	Steep slope Moderately steep slope, high susceptibility to slope failure
Secondary Roads	4	Moderately steep slope, high susceptibility to slope failure, highly dispersible subsoil
Rural Residential	5	Farm dams
Urban Residential	4	Slope, high proportion of stones and boulders, depth to hard rock

MAP UNIT SYMBOL: **Dgd**	MAP UNIT: **Devonian granitic, moderate slope**



A. GENERAL DESCRIPTION

Moderate slopes occur in the steep and rolling hills of the granitic landscape. Bleached, yellow duplex soils are common with clayey sand topsoils and mottled sandy clay loam or sandy clay subsoils. Mottles indicate impeded drainage. Occasionally boulders may outcrop or come close to the surface. Uniform sandy loams as found in units Dga and Dgc, will occur in these shallow areas. This map unit is very susceptible to sheet erosion and highly susceptible to mass movement.

SITE CHARACTERISTICS

Parent Material Age: Parent Material Lithology: Landform Pattern: Landform Element: Slope a) common: Slope b) range:	Devonian Granite/granodiorite Steep/rolling hills Hillslope 13% 11-20%	**Depth to Seas. Watertable: Flooding Risk: Drainage: Rock Outcrop: Depth to Hard Rock:**	> 1.5 m Nil Moderately well drained 0-10% 0.7-1.5 m
Potential Recharge to Groundwater: Major Native Vegetation Species: Present Land Use: Length of Growing Season		Low-moderate Blue Gum Grazing April - October	

LAND DEGRADATION

Degradation Processes	Water Erosion sheet/rill	gully	Wind Erosion	Mass Movement	Salting	Acidification
Susceptibility	Very high	Moderate	Moderate	High	Low	Low
Incidence	Moderate	Low - Mod	Low	Low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B18 (Appendix D)

A1 0-15 cm — Very dark grey (10YR3/1) light sandy clay loam, weak subangular blocky structure, peds 5-10mm, rough fabric, moderately weak consistence, high organic matter, pH 4.4. Clear transition to:

A21 15-25 cm — Greyish brown (10YR5/2) clayey sand, bleached (10YR7/3) when dry, apedal, sandy fabric, moderately weak consistence, common fine quartz gravels, pH 4.7. Clear transition to:

A22 25-40 cm — Pale brown (10YR6/3) clayey sand, bleached (10YR8/3) when dry, a few medium sized faint orange mottles, apedal, sandy fabric, loose consistence, a few fine quartz gravels, pH 4.9. Clear transition to;

B2 40-120 cm — Grey (10YR5/1) sandy clay loam, abundant medium sized distinct orange mottles, weak subangular blocky structure, peds 50-100mm, rough fabric, moderately firm consistence, common fine quartz and feldspar gravels, pH 5.5. Gradual transition to:

B3 120-140 + cm — Brown (10YR5/3) sandy loam, abundant fine distinct orange mottles, apedal, sandy fabric, many fine quartz, feldspar and mica gravel fragments, pH 6.6.

CLASSIFICATION

Factual Key:	Dy3.42 (major) Uc2.21 (minor)
Australian Soil Classification:	Eutrophic, Mottled-Subnatric, Grey Sodosol; medium, non-gravelly, loamy/clay loamy, deep
Unified Soil Group:	CL

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.4**	1.9	VL	L	D	D	S	H	L
A21	4.7	1.3	VL	VL	D	D	S	VL	L
A22	4.9	2.5	VL	VL	D	D	S	VL	H
B2	5.5	2.0	VL	L	D	D	S	VL	H
B3	6.6	7.4	VL	L	D	D	S	VL	M

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

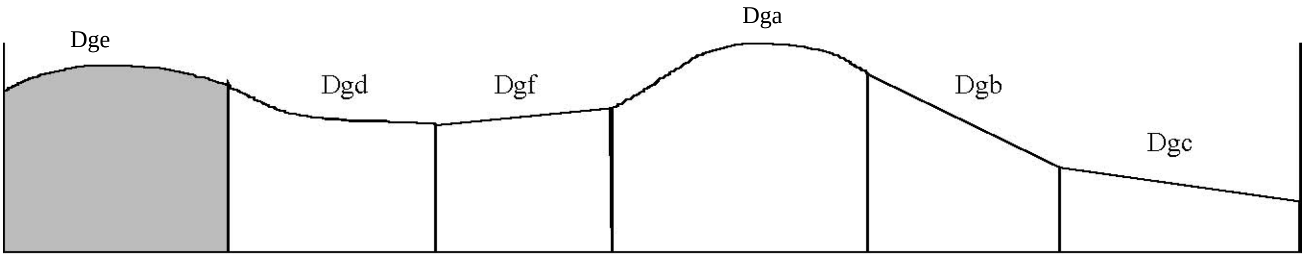
SOIL PROFILE CHARACTERISTICS:

Permeability:	Slow	(average 45 mm/day, range 20-70 mm/day)
Available Water Capacity:	Very high	(224 mm H_2O)
Linear Shrinkage (B horizon):	Low	(9%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_4S_3$	Moderately steep slopes
Effluent Disposal (septic tanks)	4	Moderately steep slopes, low permeability
Farm Dams	4	Moderately steep slopes, low suitability of subsoil, depth to hard rock, high susceptibility to slope failure
Building slab **stumps/footings**	4 4	Moderately steep slopes, high susceptibility to slope failure Moderately steep slopes, high susceptibility to slope failure
Secondary Roads	4	Moderately steep slopes, highly susceptible to slope failure, highly dispersible subsoil
Rural Residential	4	Farm dams, building foundations, secondary roads
Urban Residential	4	Slope (i), susceptibility to slope failure

MAP UNIT SYMBOL: **Dge**	MAP UNIT: **Devonian granitic, gentle crest**



A. GENERAL DESCRIPTION

The rounded gentle crests have similar soils to the steep crests (Dga). Gentle slopes occur on the lower undulating terrain. Soils are shallow uniform sandy loams, although soil depth varies considerably. These soils are highly susceptible to wind erosion and moderately susceptible to sheet erosion. Stock tend to favour these areas as camps; a habit which destroys vegetation cover and increases the incidence of erosion. Manure from these areas may contaminate associated dams.

SITE CHARACTERISTICS

Parent Material Age:	Devonian	**Depth to Seas. Watertable:**	> 1.0 m
Parent Material Lithology:	Granite/granodiorite	**Flooding Risk:**	Nil
Landform Pattern:	Steep/rolling hills	**Drainage:**	Rapidly drained
Landform Element:	Crest	**Rock Outcrop:**	0-20%
Slope a) common:	6%	**Depth to Hard Rock:**	0.5-1.0 m
Slope b) range:	4-10%		
Potential Recharge to Groundwater:		Very high	
Major Native Vegetation Species:		Blue Gum, Grey Box, Blackwood, Black Wattle, Bracken	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Moderate	Low	High	Very low	Very low	Low
Incidence	Low	Very low	Low - Mod	Very low	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B18 (Appendix D)

A1 0-10 cm Very dark greyish brown (10YR3/2) sandy loam, moderate subangular blocky structure, peds 5-10mm, rough fabric, very weak consistence, many fine granitic gravel fragments, high organic matter, pH 4.5. Clear transition to:

A21 10-20 cm Dark brown (10YR4/3) sandy loam, bleached (10YR7/3) when dry, weak subangular blocky structure, peds 10-20mm, rough fabric, moderately firm consistence, many fine granitic gravel fragments, pH 4.7. Gradual transition to:

A22 20-60 cm Dark brown (10YR4/3) sandy loam, bleached when dry (10YR7/3), apedal, sandy fabric, very strong consistence, many fine granitic gravel fragments, pH 4.5. Clear transition to:

C 60 cm Partially weathered granitic rock

CLASSIFICATION

Factual Key: Uc 2.21 (major)

Australian Soil Classification: Ochric, Paralithic, Bleached-Leptic Tenosol; thick, gravelly, sandy/loamy, moderate.

Unified Soil Group: SC

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.5**	13.6	VL	L	D	S	S	VH	L
A21	4.7	13.9	VL	VL	D	S	T	L	L
A22	4.5**	9.9	VL	L	D	S	T	M	L

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

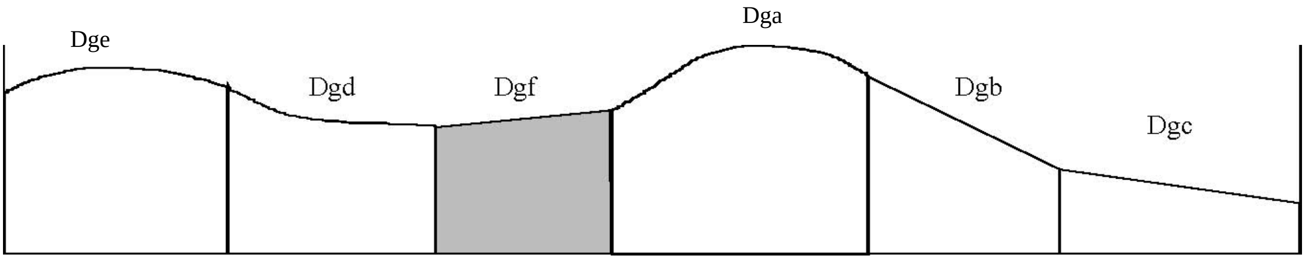
SOIL PROFILE CHARACTERISTICS:

Permeability:	Rapid	(average 1480, range 610-2,440 mm/day)
Available Water Capacity:	Low	(83 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(2%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_3S_4$	Shallow depth to hard rock, low available water capacity, highly susceptible to wind erosion
Effluent Disposal(septic tanks)	5	Rapid permeability - risk of groundwater or stream pollution
Farm Dams	5	Very low suitability of subsoil, very shallow depth to hard rock, high permeability
Building slab stumps/footings	4 4	Shallow depth to hard rock Shallow depth to hard rock
Secondary Roads	4	Shallow depth to hard rock
Rural Residential	5	Farm dams
Urban Residential	4	Depth to hard rock

MAP UNIT SYMBOL: **Dgf**	MAP UNIT: **Devonian granitic, gentle slope**



A. GENERAL DESCRIPTION

Gentle slopes occur on the elevated granitic plateau at Mt. Disappointment or the undulating plain at Pyalong. Yellow duplex soils are predominant where bleached clayey sands overlie a heavily mottled sandy clay loam or sandy clay. These mottles indicate impeded drainage. Occasionally boulders may outcrop or come close to the surface within this map unit. Uniform sandy loams, as found in units Dga and Dgb, will occur in these areas. This map unit is very susceptible to sheet erosion and highly susceptible to mass movement.

SITE CHARACTERISTICS

Parent Material Age: Parent Material Lithology:	Devonian Granite/granodiorite	**Depth to Seas. Watertable:**	> 1.5 m
Landform Pattern:	Undulating low hills	**Flooding Risk:**	Nil
Landform Element:	Hillslope	**Drainage:**	Moderately well drained
Slope a) common:	6%	**Rock Outcrop:**	0-10%
Slope b) range:	4-10%	**Depth to Hard Rock:**	> 1.5 m
Potential Recharge to Groundwater:		Low	
Major Native Vegetation Species:		Blue Gum	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low	Moderate	Moderate	Low	Low	Low
Incidence	Moderate	Low - Mod	Low	Low - Mod	Very low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B18 (Appendix D)

A1 0-15 cm Very dark grey (10YR3/1) light sandy clay loam, weak subangular blocky structure, peds 510mm, rough fabric, moderately weak consistence, high organic matter, pH 4.4. Clear transition to:

A21 15-25 cm Greyish brown (10YR5/2) clayey sand, bleached (10YR7/3) when dry, apedal, sandy fabric, moderately weak consistence, common fine quartz gravels, pH 4.7. Clear transition to:

A22 25-40 cm Pale brown (10YR6/3) clayey sand, bleached (10YR8/3) when dry, a few medium sized faint orange mottles, apedal, sandy fabric, loose consistence, a few fine quartz gravels, pH 4.9. Clear transition to;

B2 40-120 cm Grey (10YR5/1) sandy clay loam, abundant medium sized distinct orange mottles, weak subangular blocky structure, peds 50-100mm, rough fabric, moderately firm consistence, common fine quartz and feldspar gravels, pH 5.5. Gradual transition to:

B3 120-140 + cm Brown (10YR5/3) sandy loam, abundant fine distinct orange mottles, apedal, sandy fabric, many fine quartz, feldspar and mica gravel fragments, pH 6.6.

CLASSIFICATION

Factual Key:	Dy3.42 (major) Dy3.41 (minor)
Australian Soil Classification:	Eutrophic, Mottled-Subnatric, Grey Sodosol; medium, non-gravelly, loamy/clay loamy, deep.
Unified Soil Group:	CL

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.4**	1.9	VL	L	D	D	S	H	L
A21	4.7	1.3	VL	VL	D	D	S	VL	L
A22	4.9	2.5	VL	VL	D	D	S	VL	H
B2	5.5	2.0	VL	L	D	D	S	VL	H
B3	6.6	7.4	VL	L	D	D	S	VL	M

VL: Very Low L: Low M: Moderate H: High VH: Very High D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

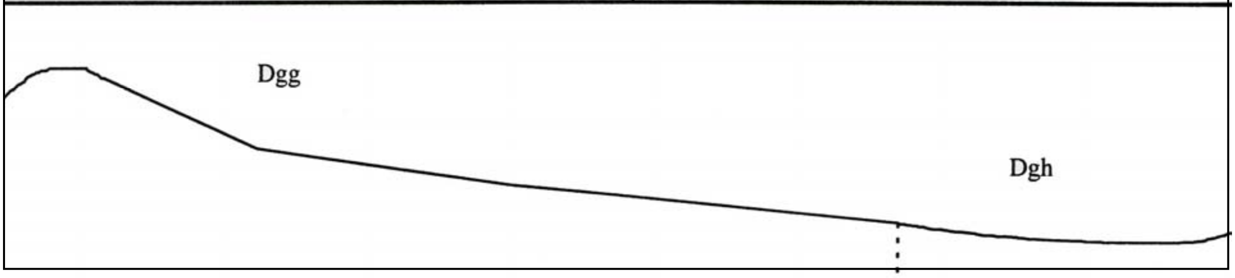
SOIL PROFILE CHARACTERISTICS:

Permeability:	Slow	(average 45 mm/day, range 20-70 mm/day)
Available Water Capacity:	Very high	(224 mm H_2O)
Linear Shrinkage (B horizon):	Low	(9%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_3S_3$	Length of growing season, moderate slopes, moderate dispersibility of topsoil
Effluent Disposal (septic tanks)	4	Low permeability
Farm Dams	4	Low suitability of subsoils, shallow depth to hard rock
Building slab **stumps/footings**	3 3	Moderately well drained, moderate slopes Moderately well drained
Secondary Roads	4	Highly dispersible subsoil
Rural Residential	4	Farm dams, secondary roads
Urban Residential	4	Drainage

MAP UNIT SYMBOL: **Dg**	MAP UNIT: **Devonian granitic, gentle slopes**



Map unit	**Dgg**	
Landform element	Gentle crest and slopes	Drainage depression
Slope range	0-10%	1-10%
Parent material	Granite, granodiorite	
Site drainage	Well drained	Moderately well drained
Dominant Vegetation	Grey Box, Red Box, Red Stringybark	Grey Box, River Red Gum
Factual Key	Dy 3.41 (major) Dy3.42 (minor)	Dy 3.41 (major) Dy3.42 (minor)
Description of common soil type	**A1** 0-15 cm Very dark grey (10YR3/1) light sandy clay loam, weak subangular blocky structure, peds 5-10 mm, rough fabric, moderately weak consistence, high organic matter, pH 4.4. Clear transition to: **A21** 15-25 cm Greyish brown (10YR5/2) clayey sand, bleached (10YR7/3) when dry, apedal, sandy fabric, moderately weak consistence, common fine quartz gravels, pH 4.7. Clear transition to: **A22** 25-40 cm Pale brown (10YR6/3) clayey sand, bleached (10YR8/3) when dry, a few medium sized faint orange mottles, apedal, sandy fabric, loose consistence, a few fine quartz gravels, pH 4.9. Clear transition to; **B2** 40-120cm Grey (10YR5/1) sandy clay loam, abundant medium sized distinct orange mottles, weak subangular blocky structure, peds 50-100 mm, rough fabric, moderately firm consistence, common fine quartz and feldspar gravels, pH 5.5. Gradual transition to: **B3** 120-140 + cm Brown (10YR5/3) sandy loam, abundant fine distinct orange mottles, apedal, sandy fabric, many fine quartz, feldspar and mica gravel fragments, pH 6.6.	**A1** 0-15 cm Very dark grey (10YR3/1) light sandy clay loam, weak subangular blocky structure, peds 5-10 mm, rough fabric, moderately weak consistence, high organic matter, pH 4.4. Clear transition to: **A21** 15-40 cm Greyish brown (10YR5/2) clayey sand, bleached (10YR7/3) when dry, apedal, sandy fabric, moderately weak consistence, common fine quartz gravels, pH 4.7. Clear transition to: **A22** 40-60 cm Pale brown (10YR6/3) clayey sand, bleached (10YR8/3) when dry, a few medium sized faint orange mottles, apedal, sandy fabric, loose consistence, a few fine quartz gravels, pH 4.9. Clear transition to; **B2** 60-130 cm Grey (10YR5/1) sandy clay loam, abundant medium sized distinct orange mottles, weak subangular blocky structure, peds 50-100 mm, rough fabric, moderately firm consistence, common fine quartz and feldspar gravels, pH 5.5. Gradual transition to: **B3** 130-150 + cm Brown (10YR5/3) sandy loam, abundant fine distinct orange mottles, apedal, sandy fabric, many fine quartz, feldspar and mica gravel fragments, pH 6.6.
Permeability	Low	Low
Rock outcrop	0-10%	0-10%
Depth to hardrock	> 1.5 m	> 1.5 m
Available water capacity	Very high	Very high

Unified Soil Group	CL	CL
Land Degradation-susceptibility	Sheet & rill - Low Gully - moderate Wind - moderate Slope failure - Low	Sheet & rill - Low Gully - moderate Wind - moderate Slope failure - Low
Land Degradation-incidence	Sheet & rill - Very low Gully - Low Wind - Very low Slope failure - Very low	Sheet & rill - Very low Gully - Low Wind - Very low Slope failure - Very low
Land Use	Sand extraction, grazing	Sand extraction, grazing
Capability for Agriculture/ major limiting features	Class 3 length of growing season, dispersibility of topsoil	Class 3 length of growing season, dispersibility of topsoil

4.5 SILURIAN/DEVONIAN SEDIMENTARY MAP UNITS

Silurian/Devonian sedimentary soils cover approximately 148 850 hectares of the Shire of Mitchell. Silurian and Devonian sedimentary map units have been combined due to the similarity between major and minor soil types. Geological age is estimated at between 367 and 446 million years. Silurian/Devonian sediments contain deeply weathered marine sandstone, mudstone and shale with minor intervals of greywacke-conglomerate. Soils vary considerably with marked changes in land use, topography and climate.

Soils common to the crests, steep and moderate slopes, are hard setting gravelly yellow duplex soils, with moderately structured sandy loams overlying whole coloured light to medium clay subsoils.

Soils common to the gentle and very gentle slopes are typically bleached, yellow duplex soils, with hard setting sandy loam topsoils over mottled medium to heavy clay subsoils.

Drainage depressions have deep, bleached yellow duplex soils with moderately structured fine sandy clay loam or silty clay loam over mottled light clays. These map units vary considerably depending on the condition of the particular catchment area.

Much of the steep sedimentary terrain has been formed through the upwelling of granitic rock through the Silurian/Devonian sediments. This has resulted in uplift, folding and metamorphism of the sedimentary rock. These areas are called metamorphic aureoles and are found adjacent to the Mt Disappointment granitic plateau. The heat associated with the upwelling granite also bakes and hardens the sedimentary rock making it less susceptible to erosion. The areas are characterised by high relief, with narrow, often rocky crests, steep side slopes, and very shallow soils.

The rocky metamorphic aureole and the widespread clearing of native vegetation have contributed to high groundwater recharge in the steeper sedimentary terrain. In many cases local groundwater discharge occurs downslope causing salting. The gentle slopes and drainage depressions of the Silurian/Devonian sediments have the highest incidence of salt affected land within the Mitchell Shire. Acidic soils are common in the sedimentary terrain.

Land management considerations
The steep terrain, including the metamorphic aureoles, have obvious hazards for all proposed land uses. The major limitations are steep slopes, depth to hard rock and shallow soil depth. The steep terrain is highly susceptible to sheet and gully erosion, especially where vegetation cover is poor. The major concerns in the gentle terrain include flooding risk, site drainage and salinity.

Salinity is considered a major problem and may require long term remedial action at a catchment wide level if control is to be achieved. The incidence of salting in this map unit is moderately high. It is advisable to become familiar with identifying its presence and associated indicator plants. Bare soils and the presence of spiny rush are good indicators of salinity. The impact of salinity on the environment can range from severe direct effects to long term indirect losses. Severe salinisation can result in total loss of soil productivity, which can be irreversible and costly, and have a direct effect on the environment through increased saline runoff, soil erosion and land and stream degradation. Care must be taken in siting residential development as building foundations, plumbing and roading are all affected by salinity. Revegetation of high recharge areas should be a priority to lower groundwater levels at discharge sites.

The siting of access tracks, building foundations, septic tanks and dams is made extremely difficult by steep slopes, depth to hard rock and shallow soils. Soil conservation measures will be required to minimise erosion during site development. Permeability and drainage is restricted on gentle slopes and drainage lines. This will inhibit standard effluent disposal fields. Modification to standard effluent disposal fields or the use of alternative effluent disposal options may need investigation.

Improved management of steep slopes and drought prone crests is required to ensure minimal land degradation in grazing areas.

Acidic soils can cause a chemical effect resulting in plant establishment failure, increase in plant disease and poor plant growth. Fertiliser response is restricted and overall productivity is reduced. Stock grazing such pastures may also be affected by acidic soils.

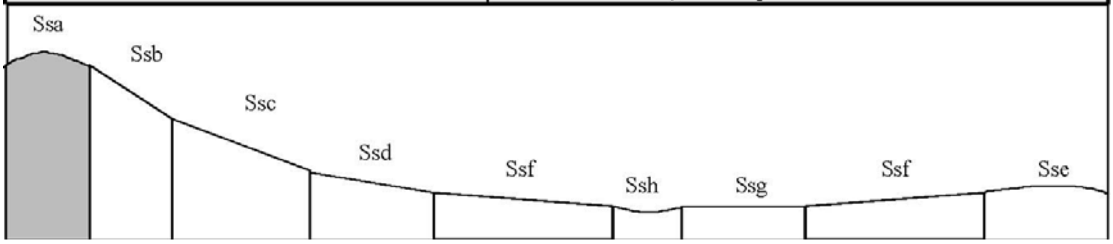
SOILS OF SILURIAN/DEVONIAN SEDIMENTARY ORIGIN

Plate 10 (M4) Map units: Ssa, Ssb, Ssc, Ssd, Sse
PPF: Dy2.11
Grey Sodosol

Plate 11 (B13) Map units: Ssf, Ssg
PPF: Dy3.41
Yellow Chromosol

Plate 12 (M5) Map unit: Ssh
PPF: dy3.41
Brown Dermosol

MAP UNIT SYMBOL: **Ssa**	MAP UNIT: **Silurian/Devonian sediments, steep crest**



A. GENERAL DESCRIPTION

Silurian/Devonian steep crests and ridgelines are common to the east of the Shire. Weakly structured, hard setting, yellow duplex soils are common, with sandy loams overlying whole coloured or mottled sandy clay loam or light clay subsoils. Soil depth is shallow and variable, and rock outcrop accounts for a large proportion of this unit. Coarse fragments are abundant throughout the soil profile. The rock outcrop combined with moderate permeability, creates a potentially high groundwater recharge area. Where these crests broaden out there is an increased depth of soil. The unit is very susceptible to wind and sheet erosion, particularly where vegetation cover has been lost.

SITE CHARACTERISTICS

Parent Material Age:	Silurian/Devonian	**Depth to Seas. Watertable:**	> 0.7 m
Parent Material Lithology:	Sediments	**Flooding Risk:**	Nil
Landform Pattern:	Steep/rolling hills	**Drainage:**	Rapidly drained
Landform Element:	Hillcrest	**Rock Outcrop:**	0-40%
Slope a) common:	8%	**Depth to Hard Rock:**	0.2-0.7 m
Slope b) range:	0-35%		
Potential Recharge to Groundwater:		High	
Major Native Vegetation Species:		Red Stringybark, Ironbark, Kangaroo grass	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low	Very low	High	Very low	Nil	Low
Incidence	Low	Nil	Moderate	Nil	Nil	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M4 (Appendix D)

A1	0-5 cm	Very dark greyish brown (10YR3/2) coarse sandy loam, weak subangular blocky structure, ped size 10-20 mm, rough fabric, subangular sedimentary medium size pebbles are abundant, pH 6.0. Gradual transition to:
B2	5-30 cm	Dark greyish brown (10YR4/2) fine sandy clay loam, weak subangular blocky structure, ped size 5-10 mm, rough fabric, many subangular sedimentary large pebbles, pH 5.5. Clear transition to:
R	30 + cm	Rock

CLASSIFICATION

Factual Key:	Dy2.11 (major) Uc2.12, Gn4.6, Dy3.41 (minor)
Australian Soil Classification:	Dystrophic, subnatric, grey Sodosol, thin, moderately gravelly, loamy, clay loamy, moderate
Unified Soil Group:	ML

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.4	55	VL	M	S	S	T	H	VL
B2	4.2	45	VL	VL	D	S	T	L-M	VL

VL: Very low L: Low M: Moderate H: High VH: Very high D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

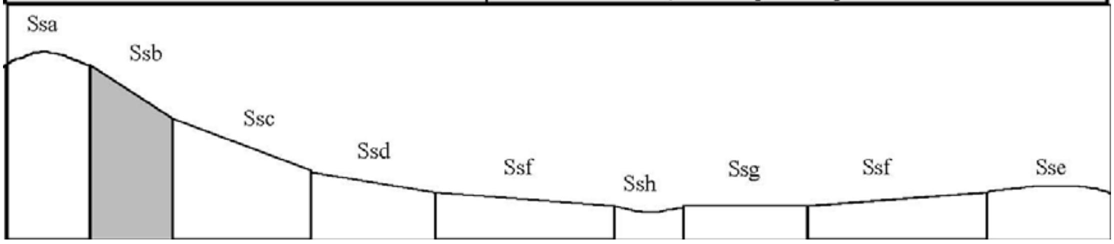
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(365 mm/day average, 240-450 mm/day range)
Available Water Capacity:	Very low	(25 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(3%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_5S_5$	Steep slopes, low available water capacity, shallow depth to hard rock, very high gravel stone and boulder content
Effluent Disposal (septic tanks)	5	Steep slopes, shallow depth to hard rock
Farm Dams	5	Steep slopes, shallow depth to hard rock, low suitability of subsoil, very high dispersibility of subsoils
Building slab **stumps/footings**	5 5	Steep slopes Steep slopes
Secondary Roads	5	Steep slopes, very high proportion of stones and boulders
Rural Residential	5	Effluent disposal, farm dams, building foundations, secondary roads
Urban Residential	5	Slope

MAP UNIT SYMBOL: **Ssb**	MAP UNIT: **Silurian/Devonian sediments, steep slopes**



A. GENERAL DESCRIPTION

These steep slopes have similar soils to those of the crests/ridges, hard setting, shallow yellow duplex soils, with moderately structured sandy loams over whole coloured light to medium clay subsoils. Both the surface and subsoils contain high levels of coarse fragments. Rock outcrop is generally less common than on the crests or ridges. Moderate permeability combined with clearing for agriculture has created a high groundwater recharge area. Steep slopes and sandy topsoils make this unit very prone to severe sheet and wind erosion. The loss of groundcover through development or grazing pressure may increase runoff contributing to the degree of erosion throughout the unit.

SITE CHARACTERISTICS

Parent Material Age: Parent	Silurian/Devonian	**Depth to Seas. Watertable:**	> 0.7 m
Material Lithology:	Sediments	**Flooding Risk:**	Nil
Landform Pattern:	Steep hills	**Drainage:**	Rapidly drained
Landform Element:	Hillslope	**Rock Outcrop:**	0-40%
Slope a) common:	39%	**Depth to Hard Rock:**	0.2-0.7 m
Slope b) range:	> 32%		

Potential Recharge to Groundwater:	High
Major Native Vegetation Species:	Red Stringybark, Ironbark, Kangaroo grass
Present Land Use:	Grazing
Length of Growing Season	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Very High	Low	High	Moderate	Nil	Low
Incidence	Moderate	Very Low	Moderate	Very Low	Nil	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M4 (Appendix D)

A1	0-10 cm	Very dark greyish brown (10YR3/2) coarse sandy loam, weak subangular blocky structure, ped size 10-20 mm, rough fabric, subangular sedimentary medium size pebbles are abundant, pH 6.0. Gradual transition to:
B2	10-30 cm	Dark greyish brown (10YR4/2) fine sandy clay loam, weak subangular blocky structure, ped size 5-10 mm, rough fabric, many subangular sedimentary large pebbles, pH 5.5. Clear transition to:
R	30 + cm	Rock

CLASSIFICATION

Factual Key:	Dy2.11 (major) Uc2.12, Gn4.64 (minor)
Australian Soil Classification:	Dystrophic, subnatric, grey Sodosol, thin, moderately gravelly, loamy, clay loamy, moderate
Unified Soil Group:	ML

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.4	55	VL	M	S	S	T	H	VL
B2	4.2	45	VL	VL	D	S	T	L-M	VL

VL: Very low L: Low M: Moderate H: High VH: Very high D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

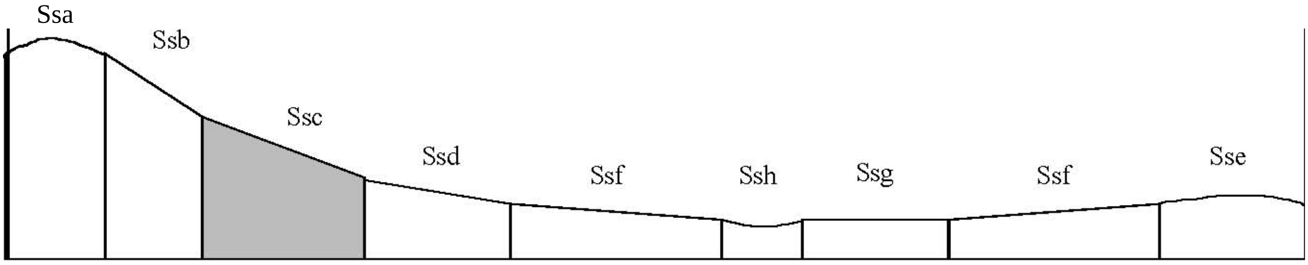
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(365 mm/day average, 240-450 mm/day range)
Available Water Capacity:	Very low	(25 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(3%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_5S_5$	Steep slopes, shallow depth to hard rock, low available water capacity
Effluent Disposal (septic tanks)	5	Steep slopes, shallow depth to hard rock
Farm Dams	5	Steep slopes, very low suitability of subsoils, shallow depth to hard rock, very low dispersibility of subsoil
Building slab **stumps/footings**	5 5	Steep slopes Steep slopes
Secondary Roads	5	Steep slopes
Rural Residential	5	Effluent disposal, farm dams, building foundations
Urban Residential	5	Slope

MAP UNIT SYMBOL: **Ssc**	MAP UNIT: **Silurian/Devonian sediments, moderately steep slope**



A. GENERAL DESCRIPTION

These moderately steep slopes have a similar but deeper soil to those of the crests and steep slopes, hard setting, shallow yellow duplex soils, with moderately structured sandy loams over whole coloured medium clay subsoils. Coarse fragment content is high in both surface and subsoils. Potential recharge to groundwater systems is high due to the high proportion of rock outcrop and moderate permeability. Sheet erosion is common, and loss of ground cover through inappropriate land management will exacerbate the severity of sheet erosion, particularly during intense summer rainfall.

SITE CHARACTERISTICS

Parent Material Age:: Parent Material Lithology:	Silurian/Devonian Sediments	**Depth to Seas. Watertable**	> 1.0 m
Landform Pattern:	Steep/rolling hills	**Flooding Risk:**	Nil
Landform Element:	Hillslope	**Drainage:**	Well drained
Slope a) common:	26%	**Rock Outcrop:**	0-20%
Slope b) range:	21-32%	**Depth to Hard Rock:**	0.5-1.0 m
Potential Recharge to Groundwater:		High	
Major Native Vegetation Species:		Red Stringybark, Ironbark, Kangaroo grass	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Very High	Low	High	Low	Nil	Low
Incidence	Moderate	Very Low	Moderate	Very Low	Nil	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M4 (Appendix D)

A1 0-10 cm Very dark greyish brown (10YR3/2) coarse sandy loam, weak subangular blocky structure, ped size 10-20 mm, rough fabric, subangular sedimentary medium size pebbles are abundant, pH 6.0. Gradual transition to:

B2 1 0-40 cm Dark greyish brown (10YR4/2) fine sandy clay loam, weak subangular blocky structure, ped size 5-10 mm, rough fabric, many subangular sedimentary large pebbles, pH 5.5. Clear transition to:

R 40 + cm Rock

CLASSIFICATION

Factual Key:	Dy2.11 (major) Dy3.41, Gn4.64 (minor)
Australian Soil Classification:	Dystrophic, subnatric, grey Sodosol, thin, moderately gravelly, loamy, clay loamy, moderate
Unified Soil Group:	ML

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.4	55	VL	M	S	S	T	H	VL
B2	4.2	45	VL	VL	D	S	T	L-M	VL

VL: Very low L: Low M: Moderate H: High VH: Very high D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

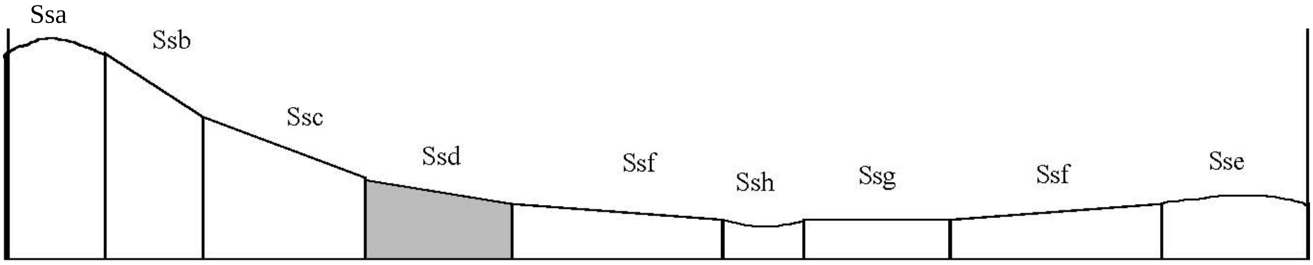
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(365 mm/day average, 240-450 mm/day range)
Available Water Capacity:	Very low	(25 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(3%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_4S_5$	Very low available water capacity
Effluent Disposal (septic tanks)	4	Moderately steep slope, shallow depth to hard rock
Farm Dams	5	Very low suitability of subsoils, shallow depth to hard rock, very low dispersibility of subsoil
Building slab stumps/footings	4 4	Moderately steep slope, high proportion of stones and boulders High proportion of stones and boulders
Secondary Roads	4	Moderately steep slope, high proportion of stones and boulders, Unified Soil Group
Rural Residential	5	Farm dams
Urban Residential	4	Slope (i), high proportion of stones and boulders

MAP UNIT SYMBOL: **Ssd**	MAP UNIT: **Silurian/Devonian sediments, moderate slope**



A. GENERAL DESCRIPTION

These moderate slopes usually mark the break in slope between steep hills and gentle undulating low hills. Soil depth is highly variable, therefore soils may range from shallow uniform soils near rock outcrop, to shallow yellow duplex soils and deeper bleached, yellow duplex soils. Shallow yellow duplex soils with sandy loam topsoils and mottled medium to heavy clay subsoils are most common. In some instances the profiles are gradational in nature with smaller texture differences between horizons. Topsoils are hard setting when dry. This unit is highly susceptible to sheet and wind erosion.

SITE CHARACTERISTICS

Parent Material Age:	Silurian/Devonian	**Depth to Seas. Watertable:**	> 1.2 m
Parent Material Lithology:	Sediments	**Flooding Risk:**	Nil
Landform Pattern:	Rolling hills/undulating low hills	**Drainage:**	Well drained
Landform Element:	Slope	**Rock Outcrop:**	0-10%
Slope a) common:	15%	**Depth to Hard Rock:**	0.5-1.2 m
Slope b) range:	11-20%		
Potential Recharge to Groundwater:		Moderate	
Major Native Vegetation Species:		Red Stringybark, Red Ironbark, Kangaroo grass	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	Water Erosion sheet/rill	gully	Wind Erosion	Mass Movement	Salting	Acidification
Susceptibility	Very High	Low	High	Low	Low	low
Incidence	Moderate	Low	Moderate	Very Low	Nil	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M4 (Appendix D)

A1 0-10 cm Very dark greyish brown (10YR3/2) coarse sandy loam, weak subangular blocky structure, ped size 10-20 mm, rough fabric, many subangular sedimentary medium pebbles, pH 6.0. Gradual transition to:

B2 10-50 cm Dark greyish brown (10YR4/2) fine sandy clay loam, weak subangular blocky structure, ped size 5-10 mm, rough fabric, many subangular sedimentary large pebbles, pH 5.5. Clear transition to:

R 50 + cm Rock

CLASSIFICATION

Factual Key:	Dy2.11 (major) Dy3.11, Dy3.41, Gn4.64 (minor)
Australian Soil Classification:	Dystrophic, subnatric, grey Sodosol, thin, moderately gravelly, loamy, clay loamy, moderate
Unified Soil Group:	ML

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.4	55	VL	M	S	S	T	H	VL
B2	4.2	45	VL	VL	D	S	T	L-M	VL

VL: Very low L: Low M: Moderate H: High VH: Very high D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

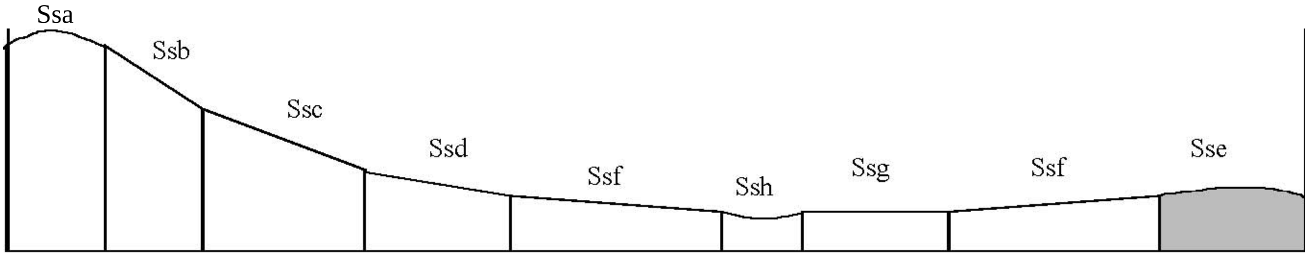
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(365 mm/day average, 240-450 mm/day range)
Available Water Capacity:	Very low	(40 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(3%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_4S_5$	Very low available water capacity
Effluent Disposal (septic tanks)	4	Shallow depth to hard rock
Farm Dams	5	Very low suitability of subsoil, shallow depth to hard rock, very low dispersibility of subsoil
Building slab **stumps/footings**	4 4	Moderately steep slopes, high proportion of stones and boulders High proportion of stones and boulders
Secondary Roads	4	Moderately steep slopes, high proportion of stones and boulders, Unified Soil Group
Rural Residential	5	Farm dams
Urban Residential	4	Slope (i), high proportion of stones and boulders

MAP UNIT SYMBOL: **Sse**	MAP UNIT:**Silurian/Devonian sediments, gentle crest**



A. GENERAL DESCRIPTION

Gentle crests generally found in the undulating and low sedimentary hills. The associated shallow soils are predominantly yellow duplex with sandy loam topsoils. In some instances the profiles are gradational in nature with smaller texture differences between horizons. Topsoils are hardsetting when dry. The soils associated with these crests are variable in depth and gravelly throughout. Nutrient status is low throughout the profile and bedrock may outcrop occasionally. Most soils are acidic.

SITE CHARACTERISTICS

Parent Material Age::	Silurian/Devonian	**Depth to Seas. Watertable**	> 1.0 m
Parent Material Lithology:	Sediments	**Flooding Risk:**	Nil
Landform Pattern:	Undulating/low hills	**Drainage:**	Well drained
Landform Element:	Crest	**Rock Outcrop:**	0-10%
Slope a) common:	4%	**Depth to Hard Rock:**	0.5-1.0 m
Slope b) range:	0-10%		
Potential Recharge to Groundwater:		Moderate – high	
Major Native Vegetation Species:		Red Stringybark, Red Ironbark, Kangaroo grass	
Present Land Use:		Grazing	
Length of Growing Season		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low	Very low	High	Very low	Nil	Low
Incidence	Very Low	Nil	Moderate	Nil	Nil	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M4 (Appendix)

A1	0-10 cm	Very dark greyish brown (10YR3/2) coarse sandy loam, weak subangular blocky structure, ped size 10-20 mm, rough fabric, subangular sedimentary medium size pebbles are abundant, pH 6.0. Gradual transition to:
B2	10-40 cm	Dark greyish brown (10YR4/2) fine sandy clay loam, weak subangular blocky structure, ped size 5-10 mm, rough fabric, many subangular sedimentary large pebbles, pH 5.5. Clear transition to:
R	40 + cm	Rock

CLASSIFICATION

Factual Key: Dy2.11 (major) Dy 3.11, Dy3.41, Uc6 (minor)

Australian Soil Classification: Dystrophic, subnatric, grey Sodosol, thin, moderately gravelly, loamy, clay loamy, moderate

Unified Soil Group: ML

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.4	55	VL	M	S	S	T	H	VL
B2	4.2	45	VL	VL	D	S	T	L-M	VL

VL: Very low L: Low M: Moderate H: High VH: Very high D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

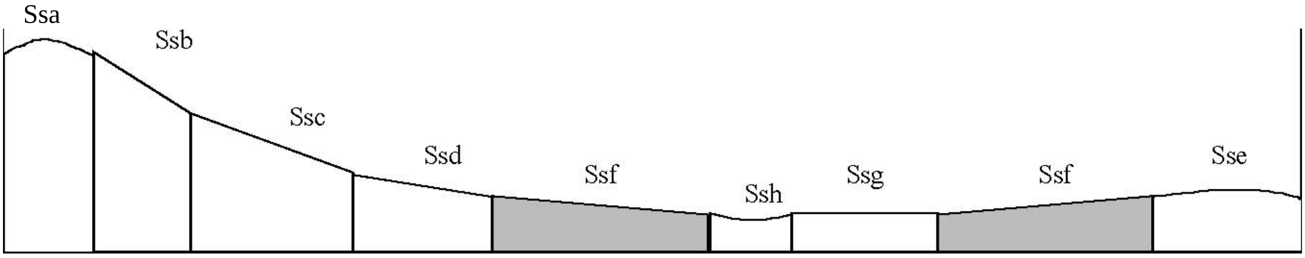
SOIL PROFILE CHARACTERISTICS:

Permeability:	Moderate	(365 mm/day average, 240-450 mm/day range)
Available Water Capacity:	Very low	(40 mm H_2O)
Linear Shrinkage (B horizon):	Very low	(3%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_2S_5$	Very low available water capacity
Effluent Disposal (septic tanks)	4	Shallow depth to hard rock
Farm Dams	5	Very low suitability of subsoil, shallow depth to hard rock, very low dispersibility
Building slab stumps/footings	3 3	Moderate slopes, moderate depth to hard rock, moderate proportion of stones and boulders Moderate depth to hard rock, moderate proportion of stones and boulders
Secondary Roads	4	Unified Soil Group, high proportion of stones and boulders
Rural Residential	5	Farm dams
Urban Residential	3	Slope (i), high proportion of stones and boulders, depth to hard rock

MAP UNIT SYMBOL: **Ssf**	MAP UNIT: **Silurian/Devonian sediments, gentle slope**



A. GENERAL DESCRIPTION

Gentle slopes are present in the undulating sedimentary terrain. The soils in this unit are bleached, yellow duplex soils. Hard setting loam topsoils overlie bleached gravelly loams and heavily mottled clays. The profiles are moderately deep. These very gentle slopes are moderately susceptible to salting, gully and wind erosion. In many instances these forms of degradation occur as a result of inappropriate land use and/or management practices.

SITE CHARACTERISTICS

Parent Material Age: Parent	Silurian/Devonian	**Depth to Seas. Watertable:**	> 1.5 m
Material Lithology:	Sediments	**Flooding Risk:**	Nil
Landform Pattern:	Undulating/low hills	**Drainage:**	Moderately well drained
Landform Element:	Hillslope	**Rock Outcrop:**	Nil
Slope a) common:	9%	**Depth to Hard Rock:**	0.6-2.0 m
Slope b) range:	4-10%		

Potential Recharge to Groundwater:	Low
Major Native Vegetation Species:	Red Stringybark, Grey Box
Present Land Use:	Native forest, grazing, cropping
Length of Growing Season	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Moderate	Moderate	Moderate	Low	Low	Moderate
Incidence	Low - Mod	Moderate	Low	Low	Low	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B13 (Appendix D)

A1 0-5 cm Dark greyish brown (10YR4/2) loam fine sandy, weak subangular blocky structure, peds 2-5 mm, rough fabric, moderately, high organic matter, pH 4.5. Abrupt transition to:

A21 5-15 cm Yellowish brown (10YR5/4) silt loam fine sandy, bleached (10YR7/4) when dry, apedal, earthy fabric, many medium sized sedimentary gravel fragments, pH 4.0. Clear transition to:

A22 15-35 cm Light yellowish brown (10YR6/4) silt loam fine sandy, bleached when dry (10YR8/4), weak subangular blocky structure, peds 10-20 mm, rough fabric, many medium sized sedimentary gravel fragments, pH 4.0. Gradual transition to:

B2 35-95 cm Brownish yellow (10YR6/6) medium-heavy clay, abundant medium sized distinct red and orange mottles, strong subangular blocky structure, peds 10-20 mm, smooth fabric, a few sedimentary gravel fragments, pH 4.5. Clear transition to:

B3 95-115 cm Light yellowish brown (10YR6/4) light-medium clay, many medium sized prominent red and pale mottles, moderate angular blocky structure, peds 5-10 mm, smooth fabric, abundant medium sized sedimentary gravel fragments, pH 4.9.

R 115 cm Rock (sedimentary)

CLASSIFICATION

Factual Key:	Dy3.41 (major), Dy3.11, Gn3.13, Uf (minor)
Australian Soil Classification:	Bleached-Sodic, Magnesic, Yellow Chromosol; medium, slightly gravelly, loamy/clayey, deep.
Unified Soil Group:	CH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.5**	5.4	VL	M	D	S	S	H	L
A12	4.0**	28.2	VL	VL	D	S	T	M	L
A22	4.0**	3.4	VL	VL	D	S	T	L	M
B2	4.5**	2.7	VL	L	D	S	T	VL	L
B3	4.9	16.3	VL	L	D	S	S	VL	L

VL: Very low L: Low M: Moderate H: High VH: Very high D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

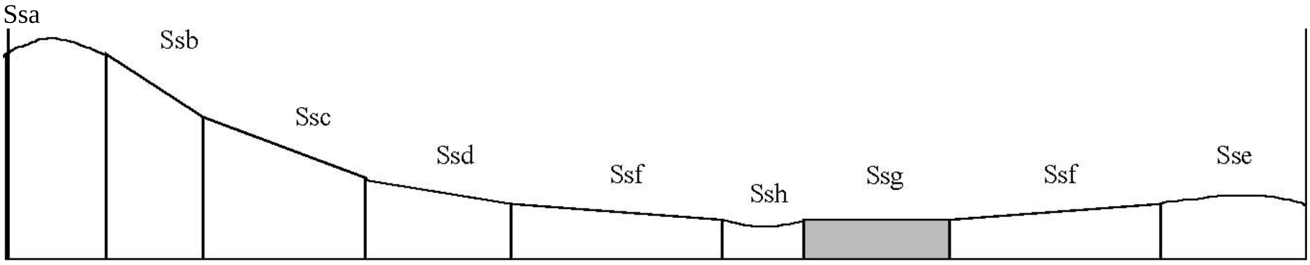
SOIL PROFILE CHARACTERISTICS:

Permeability:	Slow	(average 25 mm/day, range 10-33 mm/day)
Available Water Capacity:	Moderate	(137 mm H_2O)
Linear Shrinkage (B horizon):	Low	(10%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_3S_3$	Climate, gentle slope, moderate depth to hard rock, moderate available water capacity, moderately dispersible top soil, moderate gravel/stone/boulder content
Effluent Disposal (septic tanks)	4	Low permeability
Farm Dams	3	Shallow depth to hard rock, moderate permeability
Building slab **stumps/footings**	3 3	Moderate slopes, depth to hard rock, proportion of stones and boulders Moderate proportion of stones and boulders, depth to hard rock
Secondary Roads	3	Moderate slope, moderately well drained, Unified Soil Group
Rural Residential	3	Effluent disposal
Urban Residential	3	Slope (i), drainage, high proportion of stones and boulders, depth to hard rock

MAP UNIT SYMBOL: **Ssg**	MAP UNIT: **Silurian/Devonian sediments, very gentle slope**



A. GENERAL DESCRIPTION

Very gentle slopes are usually found throughout the undulating sedimentary low hills, particularly adjacent to drainage depressions. This unit has moderately deep, bleached, yellow duplex soils. Hard setting loam topsoils overlie bleached gravelly loams and heavily mottled clays subsoils. These very gentle slopes are moderately susceptible to salting, gully and wind erosion. In many instances these forms of degradation are due to inappropriate land use and/or management practices.

SITE CHARACTERISTICS

Parent Material Age: Parent **Material Lithology:** **Landform Pattern:** **Landform Element:** **Slope a) common:** **Slope b) range:**	Silurian/Devonian Sediments Undulating/low hills Hillslope 2% 1-3%	**Depth to Seas. Watertable:** **Flooding Risk:** **Drainage:** **Rock Outcrop:** **Depth to Hard Rock:**	> 1.5 m Nil Moderately well drained Nil 0.6-2.0 m
Potential Recharge to Groundwater: **Major Native Vegetation Species:** **Present Land Use:** **Length of Growing Season**		Low Red Stringybark, Grey Box Native forest, grazing, cropping April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low	Moderate	Moderate	Low	Moderate	Moderate
Incidence	Low	Moderate	Low	Low	Low - Mod	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION B13 (Appendix D)

A1 0-5 cm — Hardsetting dark greyish brown (10YR4/2) loam fine sandy, weak subangular blocky structure, peds 2-5 mm, rough fabric, high organic matter, pH 4.5. Abrupt transition to:

A21 5-15 cm — Yellowish brown (10YR5/4) silt loam fine sandy, bleached (10YR7/4) when dry, apedal, earthy fabric, many medium sized sedimentary gravel fragments, pH 4.0. Clear transition to:

A22 15-35 cm — Light yellowish brown (10YR6/4) silt loam fine sandy, bleached when dry (10YR8/4), weak subangular blocky structure, peds 10-20 mm, rough fabric, many medium sized sedimentary gravel fragments, pH 4.0. Gradual transition to:

B2 35-95 cm — Brownish yellow (10YR6/6) medium-heavy clay, abundant medium sized distinct red and orange mottles, strong subangular blocky structure, peds 10-20 mm, smooth fabric, a few sedimentary gravel fragments, pH 4.5. Clear transition to:

B3 95-115 cm — Light yellowish brown (10YR6/4) light-medium clay, many medium sized prominent red and pale mottles, moderate angular blocky structure, peds 5-10 mm, smooth fabric, abundant medium sized sedimentary gravel fragments, pH 4.9.

R 115 cm — Rock (sedimentary)

CLASSIFICATION

Factual Key:	Dy3.41 (major), Uf6 (minor)
Australian Soil Classification:	Bleached -Sodic, Magnesic, Yellow Chromosol; medium, slightly gravelly, loamy/clayey, deep.
Unified Soil Group:	CH

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.5**	5.4	VL	M	D	S	S	H	L
A21	4.0**	28.2	VL	VL	D	S	T	M	L
A22	4.0**	3.4	VL	VL	D	S	T	L	M
B2	4.5**	2.7	VL	L	D	S	T	VL	L
B3	4.9	16.3	VL	L	D	S	S	VL	L

VL: Very low L: Low M: Moderate H: High VH: Very high D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

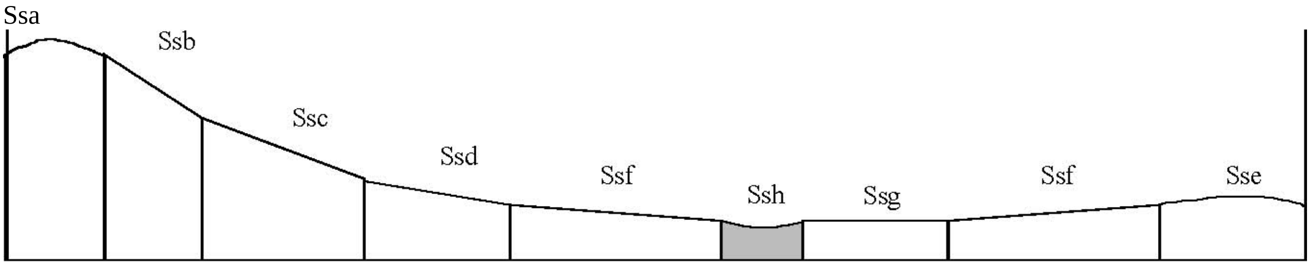
SOIL PROFILE CHARACTERISTICS:

Permeability:	Slow	(average 25 mm/day, range 10-33 mm/day)
Available Water Capacity:	Moderate	(137 mm H_2O)
Linear Shrinkage (B horizon):	Low	(10%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	C3T2S3	Length of growing season, moderate depth to hard rock, moderate available water capacity, moderately dispersible top soil, moderate gravel/stone/boulder content, moderate susceptibility to sheet, gully and wind erosion
Effluent Disposal(septic tanks)	4	Low permeability
Farm Dams	3	Moderate depth to hard rock, moderate permeability
Building slab stumps/footings	3 3	Moderately well drained, proportion of stones and boulders, depth to rock Moderately well drained, proportion of stones and boulders, depth to rock
Secondary Roads	3	Moderate drainage, Unified Soil Group
Rural Residential	3	Effluent disposal
Urban Residential	3	High proportion of stones and boulders, drainage, depth to hard rock

MAP UNIT SYMBOL: **Ssh**	MAP UNIT: **Silurian/Devonian sediments, drainage depression**



A. GENERAL DESCRIPTION

Drainage depressions within the undulating sedimentary terrain are common. The width of these drainage lines ranges between 30 m and 100 m. and the soils are variable. The dominant soil type is a poorly structured, bleached, yellow duplex soil. Fine sandy loams, including a bleached horizon, overlie a heavily mottled medium clay. Occasionally the profiles may be gradational in nature with fine sandy clay loam subsoils; some textures may also be silty. These soils generally have a deep profile. The soils in this unit are generally low in nutrients in the topsoil and can have moderate to high salt contents in the subsoil. This map unit is highly susceptible to gully erosion, wind erosion and salting. Minor flooding will often occur after intense or prolonged rainfall.

SITE CHARACTERISTICS

Parent Material Age:	Silurian/Devonian	**Depth to Seas. Watertable:**	> 1.5 m
Parent Material Lithology:	Sedimentary	**Flooding Risk:**	Low
Landform Pattern:	Undulating rises	**Drainage:**	Imperfectly drained
Landform Element:	Drainage depression	**Rock Outcrop:**	Nil
Slope a) common:	2%	**Depth to Hard Rock:**	> 1.8 m
Slope b) range:	0-7%		
Potential Recharge to Groundwater:		Low	
Major Native Vegetation Species:		River Red Gun, Yellow Box, Grey Box, Red Box	
Present Land Use:		Grazing, pasture	
Length of Growing Season:		April - October	

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	Low-moderate	Mod -high	High	Very low	Moderate	Low
Incidence	Low	Moderate	Low	Nil	Moderate	Not available

B. SOIL PROFILE

PROFILE DESCRIPTION M5 (Appendix D)

A1 0-10 cm — Dark greyish brown (10YR4/2) sandy loam, weak platy structure, rough fabric, few subrounded sedimentary medium size pebbles, pH 5.5. Clear transition to:

A21 10-15 cm — Light brownish grey (10YR6/2), bleached (10YR8/1) light clay, few medium size distinct red mottles, massive structure, earthy fabric, few subrounded sedimentary medium size pebbles, pH 6.0. Gradual transition to:

A22 15-55 cm — Brown (10YR5/3), bleached (10YR7/2) light clay, prominent red, grey and orange medium size mottles are common, massive structure, earthy fabric, few subrounded sedimentary medium size pebbles, pH 6.0. Gradual transition to:

B21 55-90 cm — Dark greyish brown (2.5Y4/2) light medium clay, many medium size prominent red, orange and grey mottles, strong subangular blocky structure, ped size 2-5 mm, smooth fabric, many subrounded sedimentary large pebbles, pH 6.0. Diffuse transition to:

B22 90-112 + cm — Olive brown (2.5Y4/3) medium clay, many coarse prominent red and orange mottles, weak angular blocky structure, ped size 20-50 mm, smooth fabric, pH 6.0.

CLASSIFICATION

Factual Key: Dy3.41 (major) Gn4.51, Uf6 (minor)

Australian Soil Classification: Mesotrophic, bleached-sodic, brown Dermosol, thick, slightly gravelly, loamy, clayey, deep

Unified Soil Group: CL

INTERPRETATION OF LABORATORY ANALYSIS*

Horizon	pH ($CaCl_2$)	% Gravel	EC (salts)	Nutrient Status	P	K	Al	Organic Matter	Dispersibility
A1	4.3**	4	L	VL	D	S	S	M	VL
A21	4.7	19	VL	VL	D	S	S	L	M
B21	5.3	39	M	L	D	S	S	VL	L
B22	5.4	19	L	L	D	D	S	VL	H

VL: Very low L: Low M: Moderate H: High VH: Very high D: Deficient S: Satisfactory
T: Potentially Toxic NA: Not Available * see Appendix D for analytical results ** Strongly Acidic

SOIL PROFILE CHARACTERISTICS:

Permeability:	Very slow	(average 3 mm/day, range 0-6 mm/day)
Available Water Capacity:	Moderate	(120 mm H_2O)
Linear Shrinkage (B horizon):	Medium	(13%)

C. LAND CAPABILITY ASSESSMENT

Land Use	Class	Major Limiting Feature(s)/Land Use
Agriculture	$C_3T_2S_3$	Length of growing season, moderate depth to hard rock, moderate available water capacity, moderately dispersible top soil, moderate gravel/stone/boulder content, moderate susceptibility to sheet, gully and wind erosion
Effluent Disposal (septic tanks)	5	Very low permeability, no. of months/year where av. daily rainfall > Ksat
Farm Dams	3	Moderate linear shrinkage, moderate depth to hard rock, moderate dispersibility of subsoil
Building slab stumps/footings	4 4	Imperfectly drained Imperfectly drained
Secondary Roads	4	Poorly drained, high dispersibility of subsoil
Rural Residential	4	Effluent disposal
Urban Residential	4	Drainage

4.6 ORDOVICIAN SEDIMENTARY MAP UNITS

Ordovician Sedimentary soils cover approximately 14 950 hectares of the Shire of Mitchell. Geological age is estimated at between 446 and 59 million years. These Ordovician sediments have been tightly folded, faulted and uplifted. Sediments often display various levels of metamorphism adjacent to the metamorphic aureole at Pyalong. The Ordovician sediments are located to the south of Heathcote, west of McIvor Creek and north west of Tooborac.

The sedimentary landscape is varied, with ridges, steep to gentle hills and wide drainage lines. A characteristic feature of the land in the steeper terrain is the presence of outcropping parallel bands of resistant sandstone interspersed with more readily weathered siltstone. These bands commonly run in a north west, or south east direction and are often exposed down to and including the upper drainage lines.

Soils vary considerably due to marked changes in land use, topography and climate.

Soil depth varies markedly in the steep terrain due to the tightly folded and faulted sedimentary geology. It is a common occurrence to find shallow soils immediately adjacent to soils approaching a depth of 1.2 metres. Adjacent to the Granitic intrusions these map units also include the more erosion resistant metamorphosed sediments of the aureole, which produce similar soil types. In general, weak, shallow and stony yellow duplex clay loam soils over sandy clay subsoils are common on rocky crests and steep rocky slopes. Weak stony yellow duplex soils predominate where soil depth increases, especially when moderate slopes are encountered. Surface stone is common on all crests and steep to moderate slopes. Weak yellow uniform soils are common on the drainage lines.

Soils of the low, undulating hills show less variation, and soil depth regularly exceeds 1.5 metres in drainage lines. Loss of vegetation cover, combined with periods of high grazing and cultivation pressure, have modified the soils. In many cases, erosion has removed much or all of the original topsoil, while cultivation has resulted in mixing of topsoils and subsoils. Many soil types present are considered to be modified soils which differ from undisturbed soils in their natural state. Soils present on gentle crests are mostly yellow duplex with uniform or gradational soils present where soils are shallow and rock outcrops occur. Bleached, mottled yellow duplex soils dominate the gentle slopes and broad drainage depressions of the low, undulating hills.

Most of the area has been cleared of native vegetation. Agriculture is restricted to grazing of native and introduced pastures on the shallow stony soils of the crests and upper slopes. Phalaris pastures have been established in some areas. On the lower slopes and some major drainage depressions there is an increase in agricultural practices with hay cut on some areas.

Sheet and gully erosion are the most common forms of land degradation, with the problem accentuated by overgrazing and compaction. Clearing of the native vegetation from the permeable soils of the upper slopes has resulted in increased percolation of rainfall through to the groundwater system. This ground water intersects the surface in some low lying areas causing significant salting.

Land management considerations

Various land degradation problems exist within the Ordovician landscape. In the steep terrain, sheet erosion and gully erosion are common were vegetation cover is sparse.

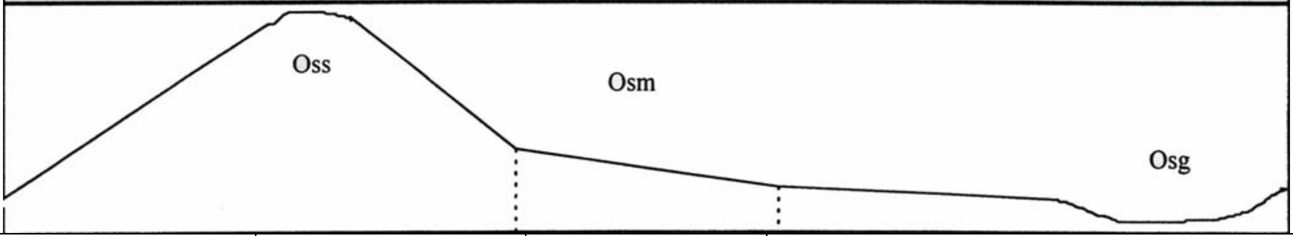
The steep Ordovician terrain, including the metamorphic aureole around the granitic rock, has obvious hazards for all proposed land uses. The major limitations are steep slopes, shallow depth to hard rock and shallow soil depth. The steep terrain is highly susceptible to sheet and gully erosion, especially where vegetation cover is poor. The siting of access tracks, building foundations, septic tanks and dams is made extremely difficult by steep slopes, depth of hard rock and shallow soils. Careful design of effluent disposal systems, farm dams and secondary roading is required. Alternative effluent disposal systems may need to be investigated. Consideration must also be given to dam construction and the impact upon environmental stream flows. Soil conservation measures will be required to minimise erosion during house construction. Improved management of steep slopes and drought prone crests is required to ensure minimal land degradation occurring in grazing areas.

The low undulating hills are more suitable to a range of land uses. The major concerns include subsoil permeability and dispersibility. This will restrict effluent disposal and secondary roading.

Poor soil structure is common on all map units of Ordovician geology. Soil conditions do not favour cropping on many of these map units. Limited cropping, however may be possible with improved land management. Limitations on grazing are less severe and can be overcome with appropriate stocking rates and correct conservation practices of summer pastures.

The presence of highly fractured rock outcrop and shallow stony soils contribute to local and regional groundwater recharge. Waterlogging and salinity discharge are common where groundwater discharges along drainage lines, gentle slopes. and below leaking dams. In these situations, Spiny Rush is a good indicator of waterlogging and saline ground. Salinity may require long term remedial action at a catchment wide level for effective control to be achieved. The incidence of salting in this map unit is moderate. Bare soils and the presence of Spiny Rush are good indicators of salinity.

MAP UNIT SYMBOL: **Os**	MAP UNIT: **Ordovician Sediments**



Map unit	**Oss**	**Osm**	**Osg**	
Landform element	Crest and steep slopes	Moderately steep to moderate slopes	Gentle to very gentle slopes	Drainage depression
Slope range	> 32%	11-32%	1-10%	1-5%
Parent material		sandstone, mudstone		
Site drainage	Well drained	Well drained	Imperfectly drained	Poorly drained
Dominant Vegetation	Red box, Grey box	Red box, Grey box, Red stringybark	Ironbark, Grey box, Red stringybark	Yellow Gum, Yellow box, Grey box
Factual Key	Dy2.11, (major) Gn3.14, Um1 (minor)	Dy2.11 (major)Gn3.14, Dy2.11, Um1 (minor)	Dy3.42 (major) Dr2.41, Uf (minor)	Dy3.42 (major) Gn4.51, Uf minor
Description of common soil type	**A1** 0-10 cm stony dark brown loam, pH 5.5 **B2** 10-25 cm stony brown light clay, pH 5.5 **B3** 25-40 cm stony light brown clay, pH 6.0 **C** 40-70 cm weathered rock **R** 70 + cm rock	**A1** 0-10 cm stony dark brown loam, pH 5.5 **B2** 10-25 cm stony brown light clay, pH 5.5 **B3** 25-40 cm stony light brown clay, pH 6.0 **C** 40-70 cm weathered rock **R** 70 + cm rock	**A1** 0-10 cm dark grey sandy loam, pH 6.0 **A2** 10-20 cm light grey sandy loam, pH 6.5 **B21** 20-70 cm mottled yellowish brown medium clay, pH 8.0 **B22** 70-90 cm mottled, dark red medium clay, pH 7.5 **BC** 90-130 cm mottled, brownish yellow light medium clay, pH 8.0 **C** 130-150 + cm weathered sedimentary rock	**A11** 0-10 cm yellowish brown sandy loam, pH6.5 **A12** 10-20 cm brown clay loam, pH 6.5 **A2** 20-50 cm very pale brown sandy clay loam, pH 7.0 **B2** 50-60 cm light yellowish brown light clay, pH 7.5 **BC** 60-110 cm light yellowish brown sandy clay, pH 8.0 **R** 110-150 cm weathered sedimentary rock
Permeability	High	Moderate	Low	Low
Rock outcrop	10-80%	0-40%	0-20%	0%
Depth to hardrock	0.2-0.6 m	0.2-1.0 m	0.5-1.5 m	1.0-1.5 m
Unified soil Group	CL	CL	CH	CL
Land Degradation-susceptibility	Sheet & rill -Very high Gully - Low Wind - Moderate Slope failure - Low	Sheet & rill -High Gully - High Wind - Moderate Slope failure Moderate	Sheet & rill - Moderate Gully - High Wind - High Slope failure - Very low	Sheet & rill -Very low Gully - Moderate Wind - Very low Slope failure-Very low
Land Degradation-incidence	Sheet & rill - Low Gully - Very low Wind - Low-moderate Slope failure -very low	Sheet & rill Moderate Gully - Low Wind - Low Slope failure -Very low	Sheet & rill - Low Gully - Low Wind - Low Slope failure - Nil	Sheet & rill -Very low Gully - Low Wind - Very low Slope failure - Nil
Land Use	Grazing	Grazing	Grazing, cultivation	Grazing
Capability for Agriculture/major limiting features	Class 5 Steep slope, depth to hard rock, available water capacity	Class 4 Moderately steep slopes, depth to hard rock, available water capacity	Class 3 Moderate slopes, length of growing season, condition of topsoil	Class 3 Length of growing season, available water capacity, electrical conductivity

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APPENDIX A. NOTES TO ACCOMPANY LAND CAPABILITY RATING TABLES

A.1 Total amount of water available to plants

Available Water Capacity (AWC) is a measure of the amount of useable water in the soil for plant growth. It is determined from the difference between the amount of water retained by the soil after drainage (field capacity) and the moisture content of a soil at wilting. (permanent wilting point). There is a reasonable correlation between soil texture and AWC (Salter and Williams 1969) (Table A.1).

Table A.1 Available water capacity of soils.

Range (mm/m)	Average value for calculations (mm/m)	Sands	Sandy loams	Loams	Clay loams	Clays
76 - 100	90	KS				
101 - 125	110	LKS	KSL			
126 - 150	130	S				SC, C
151 - 175	160	CS, LS	SL	L	SCL	
176 - 200	190	FS	FSL	CL, ZL	ZCL	ZC
201 - 225	210	LFS				

The total amount of water available to plants can be calculated by adding the amount of available water in each horizon down to a maximum depth of 2 metres.

Note that gravel content of the soil horizons should be taken into account.

Soil horizon	Texture	Depth of horizon (m)	AWC of horizon (mm/m)	Available water in horizon (mm)
A	SL	0.15	160	24
B2	SC	1.25	130	143

For example, the total amount of water in the worked example above = 167 (Class 2)

A.2 Bearing capacity

Measurements were not taken of bearing capacities.

A.3 Coarse fragment sizes

Gravel: 2 - 60 mm Cobbles: 60 - 200 mm Stones: 200 - 600 mm Boulders: 600 - 2000 mm

A.4 Linear shrinkage

The Linear Shrinkage and depth of solum can replace the value for reactivity of a soil. Reactivity is used in the Australian Standard AS 2870.2 (SAA 1977), and is based on the depth of the clay layer and its shrink-swell capacity. Different areas of Victoria are identified, with 0.6 m depth being a common cut-off mark between two categories.

A.5 Condition of the topsoil

The texture, organic matter content and the size/strength of soil aggregates all influence the general behaviour of soils when subjected to different agricultural land uses and management practices. The lack of knowledge relating the performance of soils to specific attributes does not allow values for the above criteria to be divided into meaningful classes - certainly not the 5-class system used in these land capability rating tables. The concept of "Condition of topsoil" combines the score placed on each criteria to give a total score that is then compared to a 5class rating, (Table A.2).

Table A2 Rating for topsoil condition.

Criteria	**Description**	**Score**
Texture	Sands	1
	Sandy loams	2
	Loams	5
	Clay loams	4
	Clays	3
Structure (grade)	Apedal, massive	1
	Apedal, loose	2
	Weak	3
	Moderate	4
	Strong	5
Structure(size)	Very large (> 200 mm)	1
	Large (50 - 200 mm)	2
	Moderate (10 - 50 mm)	4
	Small (2 - 10 mm)	5
	Very small (< 2 mm)	3
Organic matter content (org.C x 1.72)	Very low (< 1%)	1
	Low (1 - 2%)	2
	Moderate (2 - 3%)	4
	High (> 3%)	5
	Very low (< 4 meq/100g)	1
Nutrient status of topsoil (sum of exch. Ca, Mg, K)	Low (4-8 meq/100g)	2
	Moderate (9-18 meq/100g)	3
	High (19-30 meq/100g)	4
	Very high (> 30 meq\100g)	5
Rating for topsoil condition:	**Class**	**Total score**
	1	21 – 25
	2	16 – 20
	3	11 – 15
	4	6 - 10
	5	5

For profiles with more than one A horizon, i.e. A1 and A2, top soil conditions should be determined separately for each horizon and then averaged.

Nutrient status of topsoil: The topsoil is considered the major source of nutrients for plant growth whereas the subsoil is the more reliable source of moisture. Nutrient status of topsoil = sum of exchangeable base cations (Ca, Mg, K) (Lorimer and Schoknecht 1987).

A.6 Depth to hard rock or impermeable layer

This criterion provides a measure of the effectiveness of the soil profile in filtering the nutrient and bacterial content from the effluent. The Septic Tank Code of Practice (Environment Protection Authority et al. 1990) requires a depth of at least one metre.

A.7 Depth to seasonal watertable

The Septic Tank Code of Practice (Environment Protection Authority et al. 1990) requires a minimum of one m depth of unsaturated soil for the proper functioning of effluent disposal trenches. Ideally the groundwater table should be much lower than one m, thereby reducing the risk of a rising groundwater table influencing the effectiveness of the absorption trenches. The risk of surface salting problems also increases when a saline groundwater table rises to within 1 - 1.5 m of the soil surface.

A.8 Depth of topsoil

Topsoil depth is considered during dam construction and is used when measuring the susceptibility of topsoils to erosion (Table A.10). Depth of topsoil influences the quantity of overburden that needs to be scraped clear and kept for spreading back on a dam embankment to establish a grass cover, once the construction is completed.

A.9 Dispersibility

Sustainable land use requires that the soil be able to withstand the physical forces of cultivation and compaction without adverse structural change. Soil aggregate stability can be measured by the Emerson Aggregate Test (Emerson 1977). In the case of secondary roads, dispersion can significantly effect the condition of the road when slopes are greater than 4%. Because of the close correlation between dispersible soils and high exchangeable sodium percentages in those soils, it is unnecessary to include both criteria in the capability rating table.

A.10 Drainage

This parameter is the combination of several criteria that influence the moisture status of the soil profile, viz slope, subsurface and surface flow, water holding capacity, level of groundwater tables, perched or permanent, and permeability. Only because of its general usage, reasonable definition (McDonald et al. 1984) and direct relevance to effluent disposal fields, building foundations and secondary roads has this criterion been retained.

A.11 Electrical conductivity

The following correlation in Table A.3 between the electrical conductivity of soil samples taken from the 0 - 50 cm layer of the soil profile and soil salinity has been established. It illustrates the relationship between rating class, soil salinity, EC and site characteristics such as plant growth.

Table A.3 The effects of soil salting on plant growth.

Class	Severity of salting	E.C. dS/m *	Site characteristics
1	Nil/very low	< 0.3	Plant growth unaffected
2	Low	0.30 - 0.53	Growth of salt-sensitive plants, e.g. cereals and clover is restricted
3	Moderate	0.53 - 1.26	Patchy pasture growth; salt-sensitive plants are replaced with species that are more salt-tolerant
4	High	1.26 - 2.5	Small areas of bare ground; surviving plant species have high salt tolerance
5	Very high/severe	> 2.5	Large areas of bare ground; highly salt-tolerant plants; trees may be dead or dying

* **NB: 1000 µS/cm = 1 dS/m**

A.12 Flooding risk

Building regulations prohibit building on flood-prone land, therefore land with some risk of flooding must be identified. Flooding is unlikely to cause a septic tank to fail, however the risk of polluting the floodwaters with phosphorus, nitrogen and bacterial organisms increases with the number of effluent disposal fields involved. The dilution factor will be dependent on the quantity of floodwater.

Dams are built to intercept and store run-off water. It is not possible in these tables to distinguish between seasonal run-off and seasonal flooding; the latter poses a threat to the stability of the dam, and the risk of flooding will depend on the intensity and duration of rainfall, the run-off characteristics of the catchment and the land use within the catchment. Flooding risk is rated in Table A.4

Table A.4 Flooding risk.

Risk	Class	Limitation	Condition of flood
Nil	1	No limitation	No flooding
Low	2	Minor	Minor inundation No debris Flood return period: annual
Moderate	3	Significant	Broad, slow moving No debris Flood return period: 1 in 20 to 1 in 50 years
High	4	Major	Broad, slow moving Little debris Flood return period: 1 in 100 years
Severe	5	Prohibitive	Deep channel, fast flowing Debris carrying Flood return period: 1 in 100 years

A.13 Length of the growing season

Agricultural production is governed by moisture, temperature and photoperiod (photoperiod is taken to be consistent throughout Victoria).

Length of Growing Season (months) = 12 - (P + T)

P = Number of months where monthly evapotranspiration > average monthly rainfall

T = Number of months where mean monthly temperature < 6 ^{o}C

A.14 Number of months per year when average daily rainfall > K sat

This parameter is included (although it is closely aligned to drainage) to provide an indication from climatic, rather than soil and topographic data, of the period of time each year when effluent absorption trenches might cease to function.

Data required:

- Average monthly rainfall figures.
- Average number of wet days for each month.
- K_{sat} values.

Assumptions made:

- Evapotranspiration < 1 for winter months.
- Winter-early spring months are when problems arise.
- The soil profile is at field capacity.
- Where slope is significant, run-off = run-on.

A.15 Permeability of a soil profile (K_{sat})

Permeability is controlled by the least permeable layer of a soil profile and its ability to transmit water. Permeability is independent of climate and surface drainage. The rate at which water moves down through the soil profile is an indicator of the tendency of a soil to saturate, it is an important feature if plant growth is to be maintained in areas where rainfall is spasmodic or unreliable.

Permeability provides a measure of the rate at which a saturated soil profile will conduct water to depth. K_{sat} measurements may over-estimate the value for the disposal of effluent because the soil macropores are transmitting water, whereas the real situation must take into account the clogging effect of effluent on the bottom of effluent disposal trenches, thereby reducing the rate of water movement into the soil.

The measurement of K_{sat} often produces quite variable results even between replicates on the same site, so the setting of class limits is difficult and by necessity must be very broad. Estimates of permeability can be made using the features of the least permeable soil horizon if K_{sat} values are not available, however it should be clearly indicated where estimates have been made (Table A.5).

Table A.5 permeability characteristics of a soil profile.

Estimated permeability	**Ksat range (mm/day)**	**Time taken for saturated soil to drain to field capacity**	**Soil features**
Very Slow	< 10	Months	Absence of visible pores
Slow	10 - 100	Weeks	Some pores visible
Moderate	100 - 500	Days	Clearly visible pores
Rapid	500 - 1500	Hours	Large, continuous clearly visible pores
Very Rapid	1500 - 3000	Rarely saturated	Abundant large pores
Excessive	> 3000	Never saturated	No restriction to water movement through the soil profile

A.16 Index for permeability/rainfall

This relationship has been included to take into account the situation where a strongly structured soil with very high permeability would be assessed as having a major limitation. In a dry climate, this would be correct as the soil would be drought-prone most of the year, however in a high rainfall area such a soil may be highly productive. Conversely a soil with low permeability may experience waterlogging for extended periods in a high rainfall area, but store sufficient moisture to extend the average growing season of a low rainfall area. A method of combining permeability and rainfall is shown in Table A.6

Table A.6 Index for permeability/rainfall.

Permeability		Average annual rainfall (mm/year)				
Estimated	**Ksat (mm/day)**	**< 400**	**400 - 600**	**600 - 800**	**800 - 1000**	**> 1000**
Very Slow	< 10	High	High	Moderate	Low	Very low
Slow	10 - 100	High	Very high	High	Moderate	Low
Moderate	100 - 500	Moderate	High	Very high	High	Moderate
Rapid	500 - 1500	Low	Moderate	High	Very high	High
Very Rapid	> 1500	Very low	Low	Moderate	High	Very high

A.17 Rock outcrop

This estimate has not been included as a parameter that influences the performance of earthen dams because the parameter, depth to hard rock, is inversely correlated to the proportion of rock outcropping at the soil surface, and is a good surrogate.

A.18 Slope

As the slope increases, so too does the chance of run-on water entering effluent disposal trenches and saturating the system. In addition, run-off of unfiltered effluent is more likely to enter minor drainage depressions and water courses. The increasing incidence of algal blooms in water storages emphasises the need to eliminate the entry of unfiltered effluent into watercourses.

The best ratio of earth moved to water stored in dams occurs on land with slopes between 3-7%. Gentler slopes involve greater expense as the above ratio approaches unity, whereas steeper slopes require higher embankments for proportionally less water stored.

A.19 Susceptibility to gully erosion

No single factor can adequately represent the susceptibility of an area to the gully erosion process. A number of factors are involved and each should be scored independently and then the sum of the scores can be related back to a 5 - class rating (Table A.7).

Table A.7 Susceptibility of soil to gully erosion.

Criteria	Description	Score
Slope	< 1%	1
	1 - 3%	2
	4 - 10%	3
	11 - 32%	4
	> 32%	5
Sub-soil dispersibility	E1	5
	E2, E3(3), E3(4)	4
	E3(1), E3(2)	3
	E4, E5	2
	E6, E7, E8	1
Depth to rock/hardpan	0 - 0.5m	1
	0.6 - 1.0m	2
	1.1 - 1.5m	3
	1.6 - 2.0m	4
	> 2.0m	5
Subsoil structure	Apedal, massive Weak	1
	fine < 2 mm	3
	mod. 2 - 10 mm	2
	coarse > 10 mm Moderate	1
	fine < 2 mm	4
	mod. 2 - 10 mm	3
	coarse > 10 mm Strong	2
	fine < 2 mm	5
	mod. 2 - 10 mm	3
	coarse > 10 mm	1
	Apedal, single grained	5
Lithology of substrate	Basalt	1
	Volcanic	2
	Rhyodacite	2
	Granite	4
	Alluvium	3
	Colluvium	5
	Tillite	4
	Ordovician sandstone/mudstone	5
	Silurian sandstone/mudstone	4
Rating for susceptibility to gully erosion:	**Class**	**Total score**
	1. Very low	6 - 10
	2. Low	11 - 13
	3. Moderate	14 - 17
	4. High	18 - 20
	5. Very high	21 - 25

A.20 Susceptibility to slope failure

The instability of slopes in a catchment area of a dam poses a threat to the storage capacity of that dam. Additional costs are also involved if the dam requires regular desludging. This assessment considers that land slips are the result of factors such as soil depth, slope, soil texture, volume of water held in the soil, permeability of the solum and the underlying parent material.

Since the quantity of water in a profile is itself a function of soil texture, depth and permeability, the table below is presented as a first attempt to assess the susceptibility of land to slope failure by relating the total amount of water in the soil profile to the slope (Table A.8).

Table A.8 Susceptibility to slope failure.

Slope %	Total amount of water in the soil profile		
	Low (< 70 mm H20)	Moderate (70-170 mm H20)	High (> 170 mm H20)
Gentle < 10	Very low	Very low	Low
Moderate 10-32	Low	Moderate	High
Steep > 33	Moderate	High	Very high

A.21 Suitability of subsoil for earthen dams

In the building of earthen dams to 1000 m^3, suitability of subsoil is dependent on the nature of the material, which is represented by the Unified Soil Group classification, and depth of the material. Refer to Table A9the Unified Soil Group classification, and depth of the material.

Table A.9 Suitability of subsoil for earthen dams.

	Unified soil group of subsoil				
DEPTH OF SUBSOIL (m)	SP, SW, GP, GW, Pt, OH, OL	ML, MH	GM, CH, SM	CL	GC, SC
< 0.5	Very low	Very low	Very low	Very low	Very low
1.0 - 0.5	Very low	Low	Moderate	Moderate	Moderate
1.5 - 1.0	Very low	Moderate	High	High	High
> 1.5	Very low	Moderate	High	High	Very high

A.22 Susceptibility of soil to sheet and rill erosion by water

The following table (Table A.10) has been adapted from Elliott dispersibility (Emerson aggregate test)) and then related to slope and Leys (1991). The erodibility index for a range of soil to determine a rating for susceptibility. The final rating for properties closely relates to the susceptibility of soils to erosion susceptibility to sheet/rill erosion is read from Table A.11 once by water, and in the tables below, the same soil properties have the erodibility of the topsoil and the slope of the area have been used (texture, structure grade, topsoil depth and assessed.

Table A.10 Erodibility of topsoils.

Soil parameters			Soil Dispersibility		
Texture group (A1)	**Structure grade (A1)**	**Horizon depth (A1 + A2)**	**Very Low - Low E3(1), E3(2), E4,E5, E6, E7, E8**	**Medium - High E3(3), E3(4), E2**	**Very High E1**
Sand	apedal	< 0.2 m 0.2 - 0.4 m > 0.4 m	M L L		
Sandy loam	apedal	< 0.2 m	M	H	
		0.2 - 0.4 m	L	M	
		> 0.4 m	L		
	weakly pedal	< 0.2 m 0.2 - 0.4 m	H M	E V	
		> 0.4 m	M		
Loam	apedal	< 0.2 m	M	H	
		0.2 - 0.4 m	L	M	
		> 0.4 m	L		
	weakly pedal	< 0.2 m	H	E	
		0.2 - 0.4 m	M	V	
		> 0.4 m	M		
	peds evident	< 0.2 m	H	E	
		0.2 - 0.4 m	H		
		> 0.4 m	H		
Clay loam	apedal	< 0.2 m	M	H	
		0.2 - 0.4 m	L	M	
		> 0.4 m	L		
	weakly pedal	< 0.2 m	H	E	
		0.2 - 0.4 m	M	V	
		> 0.4 m	M		
	peds evident	< 0.2 m	H	E	
		0.2 - 0.4 m	H	E	
		> 0.4 m	M		
Light clay	weakly pedal	< 0.2 m	H	E	E
		0.2 - 0.4 m	M	V	E
		> 0.4 m	M	V	E
	peds evident	< 0.2 m	M	V	E
		0.2 - 0.4 m	M	H	E
		> 0.4 m	M	H	E
	highly pedal	< 0.2 m	H	E	
		0.2 - 0.4 m	M	V	
		> 0.4 m	M	V	
Medium to heavy clay	weakly pedal	< 0.2 m	M	H	E
		0.2 - 0.4 m	M	H	V
		> 0.4 m	M	H	V
	peds evident	< 0.2 m	H	E	E
		0.2 - 0.4 m	M	V	E
		> 0.4 m	M	V	E
	highly pedal	< 0.2 m	H	E	E
		0.2 - 0.4 m	M	V	E
		> 0.4 m	M	V	E

L - Low M - Moderate H - High V - Very high E - Extreme

Table A.11 Susceptibility of soil to sheet and rill erosion.*

Slope %	Low	Topsoil erodibility (from Table A.10) Moderate High Very high			Extreme
< 1 %	Very low	Very low	Low	Low	Moderate
1 - 3 %	Very low	Low	Moderate	Moderate	High
4 - 10%	Low	Moderate	Moderate	High	Very high
11 - 32%	Moderate	Moderate	High	Very high	Very high
> 32%	Moderate	High	Very high	Very high	Very high

*** Note:** Topsoil erodibility is determined from the texture, structure, depth and dispersibility of the topsoil (Table A.10). The susceptibility of the topsoil to sheet and rill erosion relates to the combined effect of slope and topsoil erodibility (Table A.11).

A.23 Susceptibility of soil to erosion by wind

The susceptibility of land to wind erosion is a function of (Lorimer 1985). Soil erodibility is a

very important factor soil erodibility, the probability of erosive winds when the to consider in land capability rating tables (Table A.12). soil is dry and the exposure of the land component to wind

Table A.12 Soil erodibility.

	Soil type	Rating
1	Surface soil has a strong blocky structure (aggregates > 0.8 mm), or is apedal and cohesive or has a dense layer of stones, rock or gravel	Very low
	Surface soil has strong fine structure (aggregates < 0.8 mm)	Moderate
	Surface soil has a weak-moderate structure or is apedal and loose	Go to 2
2	Surface soils with organic matter > 20%	High
	Surface soils with organic matter 7 - 20%	Moderate
	Surface soils with organic matter < 7%	Go to 3
3	Surface soils with the following textures:	
	Fine-medium sands	Very high
	Loamy sands	High
	Sandy loams, silty loams	High
	Loams, coarse sands	Moderate
	Clay loams	Low
	Clays	Very low

A.24 Susceptibility of soil to acidification

Soil acidification is usually observed over time as a decrease in soil pH. It may take place in the topsoil or subsoil. Soil acidification will cause contrasting effects depending upon the initial pH of the soil. In general, soil pH below 4.5 ($CaCl_2$) will cause toxic aluminium and manganese to be released. This causes retarded root growth in plants and may increase leaching of soluble salts and nutrients into groundwater, rivers and streams.

Measurement of susceptibility to acidification for this report is based upon the following table (Table A.13) and analysis of topsoils from each map unit.

Table A.13 Susceptibility of soil to acidification.

Susceptibility	Texture	pH ($CaCl_2$)	Annual rainfall
Low	Medium Heavy	< 4.5 All	> 450mm > 450 mm
Moderate	Medium Light	> 4.5 < 4.5	> 450 mm > 450 mm
High	Light	> 4.5	> 450 mm

Note: Land management, such as pasture species and stocking rates can contribute to acidification. Organic matter is not used as an indicator for susceptibility as its effects are complex.

APPENDIX B. WORKING TABLES FOR LAND CAPABILITY CLASSES

B.1 Agriculture

MAP UNITS	Qa1	Qa2	Qa3	Qap1	Qap2	Qva	Qvc	Qvd	Qve	Qvf	Qvg	Qvh	Qvp
Climate	3	3	3	3	3	3	3	3	3	3	3	3	3
Topography	2	1	2	2	1	1	4	3	3	3	2	3	2
Topsoil conditions A1, A2	1	1,2	2	2	2	1	1	1	1	1	1	2	1
Depth of topsoil	1	1	2	3,4	3	2	2	2	2	2	3	1	3
Depth to hard rock/pan	1	1	1	1	1	4	4	4	4	3	4	3	4
Depth to seasonal watertable	1	2	1	1	5	1	1	1	1	1	1	2	1
Available water capacity	2	1	1	1	1	4	4	3	4	3	4	1	4
Permeability-rainfall index	1	2	2	1	2	1	1	1	1	1	3	2	3
Dispersibility of topsoil	-	2	1	1	1	2	2	2	2	2	3	3	3
Gravel/stone/boulder content	1	2	2	1	2	4	4	3	3	3	4	1	4
Electrical conductivity	1	1	1	1	3	1	1	1	1	1	1	1	1
Susceptibility to sheet erosion	2	2	2	2	2	3	5	5	3	3	3	3	3
Susceptibility to gully erosion	2	2	3	3	2	1	2	2	2	2	1	3	1
Susceptibility to wind erosion	2	3	2	4	1	3	3	3	3	3	3	3	3

MAP UNITS	Dga	Dgb	Dgc	Dgd	Dge	Dgf	Ssa	Ssb	Ssc	Ssd	Sse	Ssf	Ssg	Ssh
Climate	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Topography	5	5	4	4	1	3	5	5	4	4	2	3	2	2
Topsoil conditions A1, A2	1,2	1,2	2,4	2,4	1,2	2,4	2	2	2	2	2	1,2	1,2	3,4
Depth of topsoil	1	1	1	1	1	1	4	4	4	4	4	1	1	1
Depth to hard rock/pan	4	4	3	3	4	2	5	5	4	4	4	3	3	1
Depth to seasonal watertable	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Available water capacity	4	4	1	1	4	1	5	5	5	5	5	3	3	3
Permeability-rainfall index	2	2	2	2	2	2	1	1	1	1	1	2	2	3
Dispersibility of topsoil	3	3	3	3	3	3	1	1	1	1	1	3	3	1
Gravel/stone/boulder content	5	5	3	2	3	2	5	4	4	4	4	3	3	3
Electrical conductivity	1	1	1	1	1	1	1	1	1	1	1	1	1	3
Susceptibility to sheet erosion	3	5	5	5	3	5	2	2	2	2	2	3	2	2
Susceptibility to gully erosion	2	3	3	3	2	3	1	2	2	2	1	3	3	3
Susceptibility to wind erosion	4	4	3	3	4	3	4	4	4	4	4	3	3	4

B.2 Effluent disposal.

MAP UNITS	Qa1	Qa2	Qa3	Qap1	Qap2	Qva	Qvc	Qvd	Qve	Qvf	Qvg	Qvh	Qvp
Slope	1	1	1	1	1	5	4	3	2	2	1	3	1
Flooding risk	5	5	2	3	3	1	1	1	1	1	1	1	1
Drainage	2	3	3	4	5	2	1	1	2	2	5	4	5
Depth to seasonal watertable	1	1	1	1	5	1	1	1	1	1	1	1	1
Depth to hard rock/impermeable layer	1	1	1	1	1	5	4	3	4	3	4	1	4
Number of months/year when average daily rainfall > Ksat	-	1	1	1	1	1	1	1	1	1	1	1	1
Permeability	-	2	4	2	4	2	2	2	2	2	5	4	5

MAP UNITS	Dga	Dgb	Dgc	Dgd	Dge	Dgf	Ssa	Ssb	Ssc	Ssd	Sse	Ssf	Ssg	Ssh
Slope	5	5	4	3	2	2	5	5	4	3	2	2	1	2
Flooding risk	1	1	1	1	1	1	1	1	1	1	1	1	1	3
Drainage	1	1	3	3	1	3	1	1	2	2	2	3	3	4
Depth to seasonal watertable	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Depth to hard rock/impermeable layer	5	5	2	2	4	1	5	5	4	4	4	3	3	1
Number of months/year when average daily rainfall > Ksat	1	1	1	1	1	1	1	1	1	1	1	1	1	5
Permeability	5	5	4	4	5	4	2	2	2	2	2	4	4	5

B.3 Farm dams.

MAP UNITS	Qa1	Qa2	Qa3	Qap1	Qap2	Qva	Qvc	Qvd	Qve	Qvf	Qvg	Qvh	Qvp
Slope	2	2	2	2	2	5	5	4	1	3	2	3	2
Linear shrinkage	-	1	2	2	4	3	3	3	3	3	4	3	4
Suitability of subsoil	-	3	2	2	2	5	5	5	5	5	4	3	4
Depth to seasonal watertable	3	2	1	3	5	1	1	1	1	1	1	3	1
Depth to hard rock	1	1	1	1	1	5	5	5	5	5	5	3	5
Permeability	-	4	3	4	3	4	4	4	4	4	2	3	2
Dispersibility of subsoil	-	3	3	2	3	3	3	3	3	3	3	4	3
Susceptibility to slope failure	1	1	1	2	1	1	3	3	1	2	1	2	1

MAP UNITS	Dga	Dgb	Dgc	Dgd	Dge	Dgf	Ssa	Ssb	Ssc	Ssd	Sse	Ssf	Ssg	Ssh
Slope	5	5	5	4	2	3	5	5	5	4	2	1	2	2
Linear shrinkage	1	1	2	2	1	2	1	1	1	1	1	2	2	3
Suitability of subsoil	5	5	4	4	5	4	5	5	5	5	5	2	2	2
Depth to seasonal watertable	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Depth to hard rock	5	5	4	4	5	4	5	5	5	5	5	3	3	3
Permeability	5	5	3	3	5	3	4	4	4	4	4	3	3	2
Dispersibility of subsoil	2	2	3	3	2	3	5	5	5	5	5	2	2	3
Susceptibility to slope failure	1	1	4	4	1	1	1	1	1	1	1	2	2	1

B.4 Secondary roads.

MAP UNITS	Qa1	Qa2	Qa3	Qap1	Qap2	Qva	Qvc	Qvd	Qve	Qvf	Qvg	Qvh	Qvp
Slope	1	1	2	1	1	5	4	4	2	3	2	3	1
Drainage	2	3	3	4	5	2	1	1	2	2	5	4	5
Depth to seasonal watertable	2	2	1	2	5	1	1	1	1	1	1	1	1
Proportion of stones and boulders	1	1	1	1	1	4	3	2	3	2	4	1	4
Depth to hard rock	1	1	1	1	1	4	3	3	3	2	3	2	3
Susceptibility to slope failure	1	1	1	1	1	1	3	3	1	2	1	2	1
Linear shrinkage	-	1	2	2	4	3	3	3	3	3	3	3	3
Flooding risk	5	5	2	3	3	1	1	1	1	1	1	1	1
Dispersibility of subsoil (> 4%slope)	-	-	-	-	-	2	2	2	2	2	-	4	-
USG subsoil	-	4	3	3	3	3	3	3	3	3	3	3	3

MAP UNITS	Dga	Dgb	Dgc	Dgd	Dge	Dgf	Ssa	Ssb	Ssc	Ssd	Sse	Ssf	Ssg	Ssh
Slope	5	5	4	4	3	3	5	5	4	4	2	3	2	2
Drainage	1	1	3	3	1	3	1	1	2	2	2	3	3	4
Depth to seasonal watertable	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Proportion of stones and boulders	5	5	4	3	3	2	5	4	4	4	4	1	1	1
Depth to hard rock	5	5	2	2	4	1	4	4	3	3	3	2	2	1
Susceptibility to slope failure	1	4	4	4	1	2	1	1	2	2	1	2	2	1
Linear shrinkage	2	2	2	2	2	2	1	1	1	1	1	2	2	3
Flooding risk	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Dispersibility of subsoil (> 4%slope)	2	2	4	4	2	4	1	1	1	1	1	2	2	4
USG subsoil	1	1	3	3	1	3	4	4	4	4	4	3	3	3

B.5 Building foundations, i) slab ii) stumps.

MAP UNITS	Qa1	Qa2	Qa3	Qap1	Qap2	Qva	Qvc	Qvd	Qve	Qvf	Qvg	Qvh	Qvp
Slope i); ii)	1,1	1,1	1,1	1,1	1,1	5,4	4,3	4,3	2,1	3,2	2,1	3,2	1,1
Drainage	2	3	3	4	5	2	1	1	2	2	5	4	5
Depth to seasonal watertable	2	2	2	2	5	1	1	1	1	1	1	2	1
Proportion of stones and boulders	1	1	1	1	1	4	4	3	3	3	4	2	4
Depth to hard rock	1	1	1	1	1	4	4	2	3	2	3	1	3
Susceptibility to slope failure	1	1	1	1	1	1	3	3	1	2	1	2	1
Linear shrinkage i); ii)	-	-	1,1	1,1	3,4	2,3	2,3	2,3	2,3	2,3	3,4	2,3	3,4
Flooding risk	5	5	2	3	3	1	1	1	1	1	1	2	1

MAP UNITS	Dga	Dgb	Dgc	Dgd	Dge	Dgf	Ssa	Ssb	Ssc	Ssd	Sse	Ssf	Ssg	Ssh
Slope i); ii)	5,5	5,5	5,4	4,3	3,2	3,2	5,5	5,5	4,3	4,3	3,2	3,2	2,1	2,1
Drainage	1	1	1	3	1	3	1	1	2	2	2	3	3	4
Depth to seasonal watertable	1	1	1	1	1	1	1	1	1	1	1	1	1	3
Proportion of stones and boulders	5	5	4	3	3	2	4	4	4	4	3	3	3	3
Depth to hard rock	5	5	2	3	4	2	4	4	3	3	3	3	3	1
Susceptibility to slope failure	1	4	4	4	1	2	1	1	2	2	1	1	2	1
Linear shrinkage i); ii)	1,1	1,1	1,2	1,2	1,1	1,2	1,1	1,1	1,1	1,1	1,1	1,2	1,2	2,3
Flooding risk	1	1	1	1	1	1	1	1	1	1	1	1	1	2

B.6 Rural residential development.

MAP UNITS	Qa1	Qa2	Qa3	Qap1	Qap2	Qva	Qvc	Qvd	Qve	Qvf	Qvg	Qvh	Qvp
Building foundations i), ii)	5	5	3	4	5	4	4	3	3	3	5	4	5
Farm dams	3	3	3	4	5	5	5	5	5	5	5	4	4
Effluent disposal	5	5	3	3	5	5	4	3	3	2	4	4	4
Secondary roads	5	5	3	4	5	5	4	4	3	3	5	4	5

MAP UNITS	Dga	Dgb	Dgc	Dgd	Dge	Dgf	Ssa	Ssb	Ssc	Ssd	Sse	Ssf	Ssg	Ssh
Building foundations i), ii)	5	5	4	4	4	3	5	5	4	4	3	3	3	4
Farm dams	5	5	5	4	5	4	5	5	5	5	5	3	3	3
Effluent disposal	5	5	3	3	4	3	5	5	4	3	3	3	3	4
Secondary roads	5	5	4	4	4	4	5	5	4	4	4	3	3	4

B.7 Urban development.

MAP UNITS	Qa1	Qa2	Qa3	Qap1	Qap2	Qva	Qvc	Qvd	Qve	Qvf	Qvg	Qvh	Qvp
Building foundations i), ii)	5	5	3	4	5	4	4	3	3	3	5	4	5

MAP UNITS	Dga	Dgb	Dgc	Dgd	Dge	Dgf	Ssa	Ssb	Ssc	Ssd	Sse	Ssf	Ssg	Ssh
Building foundations i), ii)	5	5	4	4	4	3	5	5	4	4	3	3	3	4

APPENDIX C. SPECIFIC METHODOLOGY

C.1 Map unit determination

Map units were delineated according to geology and slope category (McDonald et al. 1984) using geological mapping, topographical mapping, aerial photography and field survey techniques.

C.2 Field observations

Most field descriptions are based on McDonald et al. (1984), Northcote (1979) and Isbell (1994). The definition for soil horizon boundaries is listed below.

S Sharp < 5 mm **A** Abrupt 5 - 20 mm **C** Clear 20 - 50 mm **G** Gradual 50 - 100 mm **D** Diffuse > 100 mm
+ Continuing

C.3 Field tests

C.3.1 Saturated hydraulic conductivity

Site selection:
Considerable time and effort is required to obtain meaningful permeability (K_{sat}) values. It is imperative that sites are chosen carefully prior to the day of measurement. The sites should have nil, or at most, minimal disturbance.

Procedure:

i) Insert five small (35 cm diameter) and five large (40 cm diameter) infiltration rings with the small rings placed inside the large rings, so that each ring is approximately 100 mm into the main clay horizon. Remove some topsoil if necessary but care should be taken to cause minimal soil disturbance.

ii) Rings need to be at least two metres apart and located at random. Relocate rings if obstacles such as stones or roots prevent an even downward movement of the ring into the soil.

iii) Fill rings with water and set up reservoir tanks so that water is added when the level drops below the outlet tube. Record the time and date on field sheets.

iv) Place lids on rings to minimise evaporation and interference.

v) Check that all containers are full and will last overnight to allow soil to saturate and conductivity rate to equilibrate.

vi) Record water levels at various times during the day (depending upon infiltration rate), and leave for 24 hour period without any interruptions to the water flow, if possible .

vii) Next day dig out each ring taking care not to disturb the soil contained within the ring. Up-end the ring and record the proportion of soil area that has been transmitting water for each ring and record if water movement has been evenly distributed or confined to root/worm holes or structural cracks. Note any other differences, i.e. rocks, sand, clay patches.

C.4 Laboratory analysis

Samples collected for each soil horizon were air dried, ground with a mortar and pestle and separated with 4.75 and 2 mm sieves into a gravel fraction (4.75 - 2 mm), and soil. The gravel fraction was reported as a percentage of the air dried field sample and discarded, while all subsequent tests were carried out on the soil samples and reported in terms of oven dried (105 ^{o}C) samples (except for EC, pH and Cl).

C.4.1 Physical properties

1. Particle size analysis
The method used for particle size analysis is based upon that of Hutton (1956), which divides the soil sample into the following four principal size groups:

Coarse sand 2.0 - 0.20 mm Fine sand 0.20 - 0.02 mm Silt 0.02 - 0.002 mm Clay < 0.002 mm

In this method the soil sample is mechanically dispersed using pentasodium triphosphate (sodium tripolyphosphate), shaken in a sedimentation cylinder, and silt and clay percentages determined on a 2% soil water mixture using a plummet balance. After hand decanting the silt and clay suspension, the sand fractions are determined by sieving and weighing the oven dried (105 ^{o}C) sand fractions.

Due to the presence of both organic material and solutes in the soil and also due to the limitations of the technique used, the sum of the four fractions does not always equal 100%. Limits of 4% variation for surface horizons and 2% variation for lower horizons are regarded as acceptable. The determination is repeated for samples outside these limits. If repeat samples still remain outside these limits, then the closest result is accepted.

2. Emerson class
Soil dispersion is tested using the method of Emerson, (1967), and based upon the Australian Standard AS1289, C8.1, (1980). This gives eight dispersion classes from E1 to E8, where E1 is the most dispersive class and E8 the least dispersive class. Class E5 was further divided into four sub-classes E5(A), E5(B), E5(C) and E5(D), where E5(A) is more dispersive than E5(D). Also, classes E2 and E3 were each divided into four sub-classes according to the modification of Loveday and Pyle (1973), as quoted in Craze and Hamilton (1991). In this classification E2(1) is less dispersive than E2(4) and E3(1) is less dispersive than E3(4).

The order of soil dispersion from most dispersive to least dispersive is therefore:

E1 E2(4), E2(3), E2(2), E2(1) E3(4), E3(3), E3(2), E3(1) E4 E5(A), E5(B), E5(C), E5(D) E6 E7 E8

3. Atterberg limits
Atterberg investigated the behaviour of fine grained soil with varying water content. He used the following definitions, quoted in Hicks (1991):

(a) The liquid limit is the water content at which a trapezoidal groove of specified shape, cut in moist soil held in a special cup, is closed after 25 taps on a hard rubber plate.

(b) The plastic limit is the water content at which the soil begins to break apart and crumble when rolled by hand into threads three mm in diameter.

(c) The shrinkage limit is the water content at which the soil reaches its theoretical minimum volume, as it dries out from a saturated condition.

The plasticity index is the difference between the liquid and plastic limits, and represents the range of water contents that the soil remains in the plastic state.
Atterberg limits are determined on a sieved soil fraction with particles < 0.425 mm in size. The methods are based upon the Australian Standard 1289 (1977), as follows:

Liquid limit AS1289. C1.1 Plastic limit AS1289. C2.1 Plasticity index AS1289. C3.1 Linear shrinkage AS1289. C4.1

C.4.2 Chemical properties
Soil chemical analyses were carried out by the State Chemistry Laboratory, South Road, Werribee, Vic., 3030.

1. EC, pH, and Cl determinations
These determinations are carried out on a 1:5 soil water suspension shaken for one hour, and allowed to equilibrate.

(a) Electrical conductivity
This test is used to estimate the concentration of soluble salts in the soil. Measurements are made on the soil water suspension using a dip cell and direct reading meter. Values are determined at 25 ^{0}C.

State Chemistry Laboratory, Method 004, July 1986.

(b) pH in H_2O at 20 ^{0}C
The pH of the above suspension is determined using a calomel electrode and digital pH meter.

State Chemistry Laboratory, Method 009 (1986).

(c) pH in $CaCl_2$
This is carried out on the soil water suspension after the pH in H_2O determination. One mL of 1M calcium chloride solution is added to the soil water suspension, and the mixture stirred. The pH is then measured again.

State Chemistry Laboratory, Method 009 (1986).

(d) Chloride
A fresh 1:5 soil water suspension is titrated with a silver nitrate solution, using an electrical circuit to determine the end point of the titration. Note that this determination may be omitted if the EC determination is < 0.1 dS/m.

State Chemistry Laboratory, Method 003 (1982).

2. Oxidizable organic carbon
In this determination the soil sample is oxidised by chromic acid in the presence of excess sulphuric acid, without the application of external heat (Walkley and Black, 1934). The colour produced is measured with a spectrophotometer.

State Chemistry Laboratory, Method 014 (1987).

3. Total nitrogen
Total nitrogen is determined by a Kjeldahl method, where the sample is digested with a sulphuric acid/selenious acid mixture. The resulting solution is analysed for nitrogen colorimetrically.

State Chemistry Laboratory, Method 021 (1985).

4. Available potassium
The Skene method is used where soil potassium is extracted with 0.05M hydrochloric acid, and the potassium determined with an atomic absorption spectrophotometer (Skene 1956).

State Chemistry Laboratory, Method 011 (1987).

5. Available phosphorus
Phosphorus is determined by the Olsen method in which the soil phosphorus is extracted with a 0.5M sodium bicarbonate solution at pH 8.5, (Olsen et al. 1954). The phosphorus is then measured colourimetrically after reduction with ascorbic acid.

State Chemistry Laboratory, Method 010 (1982).

6. Exchangeable aluminium and manganese
The soil sample is extracted with a 1M potassium chloride solution, and both determinations are made on the one extract. Aluminium is determined colourimetrically using pyrocatechol violet. Manganese is determined by atomic absorption spectrophotometry.

State Chemistry Laboratory, Method 001 (1985).

7. Extractable bases, calcium, magnesium, potassium and sodium
The bases are extracted from the soil with a 1M ammonium acetate solution at pH 7, and the bases are then analysed by atomic absorption spectroscopy.

State Chemistry Laboratory (1993) - draft procedure.

8. Total exchangeable bases

This is a calculated value consisting of the sum of the exchangeable bases calcium, magnesium, potassium and sodium, as determined in method 7 (above).

9. Exchangeable hydrogen

The exchangeable hydrogen is extracted from the soil using 0.053N triethanolamine and back titrated with 0.2M hydrochloric acid. This is a method modified by Peech et al. (1962).

State Chemistry Laboratory, Method 005 (1984).

10. Cation exchange capacity
This is a calculated value consisting of the sum of the exchangeable bases calcium, magnesium, potassium and sodium plus exchangeable hydrogen, as determined in methods 7 and 9 (above).

APPENDIX D. CHEMICAL LABORATORY RESULTS

Map Unit	Site Number	Laboratory Number	Horizon	Horizon Depth cm	Air Dry Water Content %	Particle Size Distribution: Gravel > 2mm %	Coarse sand %	Fine Sand %	Silt %	Clay %	Total Fine Earth %	Fines<0.074 mm %	Emerson Class	Atterberg Limits: Liquid Limit %	Plastic Limit %	Linear Shrinkage %	Plasticity Index %
Qap2	M1	960320	A1	0-9	4.08	60	4	26	25	42	97	87	E8				
Qap2	M1	960321	B21	32.0	5.39	6	1	18	18	62	99	96	E7	86	27	18	59
Qap2	M1	960322	B22	75.0	4.63	37	0	19	18	64	101	99	E2(1)	85	24	18	61
Qap2	M1	960323	B23	114.0	4.67	19	1	18	16	64	98	97	E2(1)				
Qa3	M2	960324	A1	0-18	1.37	0	5	55	29	13	102	75	E8				
Qa3	M2	960325	B1	66.0	1.37	1	1	48	26	26	101	89	E5(A)	24	14	7	10
Qa3	M2	960326	B21	80.0	2.22	1	1	52	17	29	99	75	E5(A)	31	15	10	17
Qap1	M3	960327	A1	0-13	0.90	0	3	63	30	7	102	87	E7				
Qap1	M3	960328	A2	27.0	0.20	0	1	61	33	7	102	93	E7				
Qap1	M3	960329	B2	80.0	2.47	2	1	39	28	32	100	96	E3(4)	37	14	12	24
Ssa	M4	960330	A1	0-6	3.71	58	27	24	33	12	96	57	E7				
Ssa	M4	960331	B1	28.0	1.61	45	18	21	43	19	101	76	E7	35	29	3	7
Ssh	M5	960332	A1	0-12.5	0.97	4	7	54	26	12	99	72	E7				
Ssh	M5	960333	A21	17.5	1.18	19	6	28	41	24	98	89	E3(4)				
Ssh	M5	960334	B2	53-92	2.11	39	4	23	35	38	100	91	E5(D)	42	17	13	25
Ssh	M5	960335	B3	112.0	1.61	19	2	49	23	25	100	86	E2(2)	28	13	11	14
Qa2	B11	930372	1A1	0-5	3.72	<1	1	50	31	19	101		E3(1)				
Qa2	B11	930373	1A2	17.0	3.07	2	0	53	34	16	103		E3(1)				
Qa2	B11	930374	2A	30.0	1.96	<1	0	52	27	23	102		E3(1)				
Qa2	B11	930375	3A	45.0	3.87	<1	1	49	34	16	99	78	E3(4)	28	22	4	6
Qa2	B11	930376	4A	80.0	3.21	2	1	52	32	16	101		E3(4)				
Qa2	B11	930377	4B	120.0	2.04	<1	1	52	27	18	99	74	E2(3)	24	17	15	7
Qvf	B4	930339	A	0-18	12.99	5	5	23	35	40	102		E5A				
Qvf	B4	930340	B	48.0	12.52	28	4	14	21	63	103	92	E5A	61	48	17	13
Qvf	B4	930341	BC	72.0	15.23	33	18	42	28	17	105		E5B				
Qvg	B2	930330	A11	0-7	9.94	21	2	19	21	48	90		E3(1)				
Qvg	B2	930331	A12	15.5	10.80	16	3	24	26	49	102		E3(1)				
Qvg	B2	930332	B21	43.0	6.84	27	4	14	15	62	95	85	E5A	90	36	19	54
Qvg	B2	930333	B22	67.0	11.01	30	5	21	23	49	98		E5A				
Qvg	B2	930334	B23	72.0	9.95	41	15	22	12	49	98		E5A				
Dga	B17	930492	A1	0-10	1.95	14	44	27	15	9	95		E3(1)				
Dga	B17	930493	A21	27.0	1.31	14	52	24	14	7	98	35	E3(2)	20	18	2	2
Dga	B17	930494	A22	58.0	1.00	10	16	52	19	12	99		E5B				
Dgc	B18	930495	A1	0-15	4.28	2	38	26	15	16	95		E3(2)				
Dgc	B18	930496	A21	25.0	0.41	1	46	37	10	6	99						
Dgc	B18	930497	A22	40.5	0.23	2	47	38	11	5	101		E2(1)				
Dgc	B18	930498	B2	118.0	2.44	2	36	24	11	30	101	55	E2(2)	36	23	9	12
Dgc	B18	930499	B3	140.0	2.39	7	38	29	20	13	100		E3(3)				
Ssf	B13	930385	A1	0-6.5	5.79	5	10	44	19	23	96		E3(1)				
Ssf	B13	930386	A21	17.0	2.12	28	7	42	31	19	99		E3(2)				
Ssf	B13	930387	A22	37.0	1.25	34	9	37	29	24	98		E3(3)				
Ssf	B13	930388	B2	95.0	10.59	3	1	12	17	67	97	91	E3(1)	63	24	10	39
Ssf	B13	930389	B3	110.0	6.87	16	2	24	27	47	100		E5D				

Map Unit	Site Number	Laboratory Number	Horizon	1:5 Soil Water Suspension			Oxidizable Org. Carbon %	Total Nitrogen %	Skene K ug/g	Olsen P ug/g	Exchangeable Al+++ ug/g	Extractable Bases				Total of Extractable Bases	Exchangeable H+ meq/100g	Cation Exchange Capacity
				pH H_2O	pH $CaCl_2$	EC dS/m						Ca ++ meq/100g	Mg++ meq/100g	Na+ meq/100g	K+ meq/100g			
Qap2	M1	960320	A1	5.4	4.7	0.17	>5 *	0.44	238	9.3	16	6.26	13.55	1.15	0.84	21.8	20.9	42.7
Qap2	M1	960321	B21	6.4	5.2	0.10	2-5 *	0.20	167	1.9	<10	7.72	25.37	1.69	0.72	35.5	10.1	45.6
Qap2	M1	960322	B22	6.4	5.5	0.25	1-2 *	0.09	189	1.5	<10	6.50	27.26	3.36	0.85	38.0	10.3	48.3
Qap2	M1	960323	B23	6.1	5.8	0.76	1-2 *	0.12	134	<1	<10	5.77	25.18	5.77	0.69	37.4	8.8	46.2
Qa3	M2	960324	A1	5.2	4.5	0.16	>5 *	0.27	208	12.4	16	3.24	0.65	0.19	0.54	4.6	11.0	15.6
Qa3	M2	960325	B1	5.9	4.9	<0.05	<1 *	<0.05	154	1.2	<10	3.35	0.76	0.09	0.40	4.6	3.4	8.0
Qa3	M2	960326	B21	7.6	6.5	<0.05	<1 *	<0.05	251	<1	<10	5.83	2.05	0.09	0.65	8.6	2.0	10.6
Qap1	M3	960327	A1	5.3	4.3	0.10	2-5 *	0.19	208	14.0	17	1.72	0.40	0.28	0.53	2.9	7.1	10.0
Qap1	M3	960328	A2	4.8	4.2	0.11	<1 *	0.05	87	3.2	35	0.53	0.18	0.16	0.20	1.1	1.6	2.7
Qap1	M3	960329	B2	5.0	4.6	<0.05	1-2 *	<0.05	85	<1	35	2.26	3.59	0.34	0.30	6.5	4.7	11.2
Ssa	M4	960330	A1	5.2	4.4	0.17	>5 *	0.85	658	16.4	27	5.61	2.91	0.41	1.66	10.6	25.8	36.4
Ssa	M4	960331	B1	4.9	4.2	0.10	2-5 *	0.17	204	3.4	213	0.86	0.66	0.26	0.47	2.2	13.8	16.0
Ssh	M5	960332	A1	5.3	4.3	0.05	2-5 *	0.08	172	1.5	28	1.21	1.41	0.11	0.44	3.2	6.9	10.1
Ssh	M5	960333	A21	5.6	4.7	0.11	1-2 *	0.09	114	<1	11	0.71	2.73	0.45	0.34	4.2	5.9	10.1
Ssh	M5	960334	B2	5.6	5.3	0.83	<1 *	0.07	142	<1	<10	0.20	5.01	2.66	0.48	8.3	4.7	13.0
Ssh	M5	960335	B3	6.0	5.4	0.32	<1 *	0.05	95	<1	<10	0.09	4.47	1.52	0.32	6.4	2.6	9.0
Qa2	B11	930372	1A1	5.5	4.5	0.13	3.10	0.24	115	4.5	11	3.6	2.7	0.5	0.3	7.1	11.7	18.8
Qa2	B11	930373	1A2	5.5	4.6	0.11	2.10	0.15	85	2.7	13	3.2	2.6	0.4	0.2	6.4	9.6	16.0
Qa2	B11	930374	2A	5.6	4.7	0.15	1.90	0.13	67	2.0	<5	4.0	3.1	0.7	0.2	8.0	9.6	17.6
Qa2	B11	930375	3A	5.8	4.7	0.09	1.30	0.08	58	1.4	6	3.2	2.9	0.5	0.1	6.7	6.9	13.6
Qa2	B11	930376	4A	6.5	5.3	0.07	1.00	<0.05	38	3.7	<5	3.3	3.9	0.6	0.1	7.9	4.9	12.8
Qa2	B11	930377	4B	8.1	6.8	0.10	0.60	<0.05	39	5.2	<5	3.0	4.4	1.0	0.1	8.5	2.2	10.7
Qvf	B4	930339	A	5.7	4.7	0.04	3.00	0.28	56	3.6	<5	12.3	5.2	0.3	0.2	18.0	18.0	36.0
Qvf	B4	930340	B	6.4	5.5	0.06	1.70	<0.05	69	2.6	<5	17.1	9.4	0.3	0.2	27.0	15.2	42.2
Qvf	B4	930341	BC	7.0	6.5	0.05	0.78	<0.05	25	2.1	<5	17.9	10.4	0.3	0.1	28.7	9.9	38.6
Qvg	B2	930330	A11	5.9	4.9	0.07	5.90	0.45	142	10.2	<5	22.8	12.6	0.2	0.3	35.9	20.1	56.0
Qvg	B2	930331	A12	5.8	4.8	0.06	3.70	0.29	81	6.7	<5	23.1	12.9	0.2	0.2	36.4	21.7	58.1
Qvg	B2	930332	B21	6.2	5.2	0.10	1.40	0.12	72	3.1	<5	24.6	19.0	0.4	0.2	44.2	14.9	59.1
Qvg	B2	930333	B22	6.6	5.7	0.11	1.80	0.13	80	4.0	<5	21.0	18.4	0.4	0.2	40.0	12.7	52.7
Qvg	B2	930334	B23	7.4	6.5	0.09	0.74	<0.05	84	<1.0	<5	22.6	22.7	0.3	0.2	45.8	7.2	53.0
Dga	B17	930492	A1	5.6	4.5	0.05	3.10	0.15	300	<1.0	11	3.7	0.7	0.2	0.5	5.1	11.7	16.8
Dga	B17	930493	A21	5.8	4.7	0.04	1.00	<0.05	221	1.4	24	2.7	0.4	0.1	0.4	3.6	5.7	9.3
Dga	B17	930494	A22	5.5	4.5	0.07	1.40	0.07	270	<1.0	17	3.6	0.6	0.2	0.5	4.9	8.0	12.9
Dgc	B18	930495	A1	5.7	4.4	0.04	3.40	0.24	67	2.2	11	4.6	2.3	0.3	0.1	7.3	13.4	20.7
Dgc	B18	930496	A21	6.1	4.7	0.03	0.42	<0.05	41	<1.0	<5	1.3	0.7	0.2	<0.1	2.2	2.2	4.4
Dgc	B18	930497	A22	6.1	4.9	0.05	0.22	<0.05	36	<1.0	<5	0.7	0.4	0.2	<0.1	1.3	1.2	2.5
Dgc	B18	930498	B2	7.0	5.5	0.06	0.29	<0.05	48	<1.0	<5	2.9	3.3	1.0	0.1	7.3	5.0	12.3
Dgc	B18	930499	B3	8.1	6.6	0.09	0.18	<0.05	44	<1.0	<5	3.8	4.4	1.9	0.1	10.2	2.0	12.2
Ssf	B13	930385	A1	5.4	4.5	0.14	10.4	0.60	357	4.6	13	8.7	5.3	0.4	0.8	15.2	28.1	43.3
Ssf	B13	930386	A21	5.1	4.0	0.06	1.70	0.11	176	1.7	163	0.3	0.9	0.2	0.4	1.8	12.0	13.8
Ssf	B13	930387	A22	5.2	4.0	0.06	0.73	0.05	139	<1.0	134	0.1	0.8	0.2	0.3	1.4	7.6	9.0
Ssf	B13	930388	B2	5.6	4.5	0.06	0.44	0.09	243	<1.0	227	0.1	6.5	0.4	0.7	7.7	11.7	19.4
Ssf	B13	930389	B3	6.2	4.9	0.07	0.22	0.09	149	<1.0	<5	<0.1	7.0	1.0	0.4	8.4	6.3	14.7

* Organic matter estimate

APPENDIX E. CRITERIA USED FOR ESTABLISHING RECHARGE VALUES

Characteristics of Very High Recharge Areas	
permeability of profile:	> 1000 mm/day
Characteristics of High Recharge Areas	
Soil depth: and/or outcropping bed-rock: and/or permeability of profile: and/or clay content of clayiest layer: and/or soil type Side slopes:	< 25 cm > 10% 200 - 1000 mm/day < 25% Uniform soils: uniform sands, loamy sands, uniform loams, sandy silt loams, loams (Uc, Um, Gc) Duplex soils: red and whole coloured A2 present but not bleached high Fe_2O_3 content throughout B horizon > 25%
Characteristics of Moderate Recharge Areas	
Soil depth: Outcropping bed-rock: Profile permeability: Clay content of clayiest layer: Soil type:	25 - 100 cm 1 - 10% 50 - 200 mm/day > 25 - 35% Gradational Duplex acid, whole coloured Duplex, A2 may be present and sporadically bleached
Characteristics of Low-Nil Recharge Areas	
Soil depth: Outcropping bed-rock: Profile permeability: Clay content of clayiest layer: Soil type:	> 100 cm = 0 < 50 mm/day > 35% Uniform clays (Uf) Uniform cracking clays (Ug) Duplex soils with conspicuously bleached A2, mottled B horizons and/or gleying characteristics.

GLOSSARY

The following definitions have been extracted from Charmin and Murphy (1991) and McDonald et al. (1984).

Acidification:
An increase in acidity in the soil due to changes in land use, particularly agriculture. Soils that are most susceptible are generally of light texture in high rainfall areas.

Aluminium (Al) toxicity:
Plant growth in agricultural crops may be affected if aluminium levels are greater than 15 µg/g. For the purposes of this report soils with aluminium levels greater than 15 µg/g are regarded as being potentially toxic and lime may be required to promote plant growth. (State Chemistry Laboratory, pers. comm.).

Apedal:
Describes a soil in which none of the soil material occurs as peds in the moist state. Such a soil is without apparent structure and is typically massive or single-grained.

Available water for plant growth:
The amount of water in the soil that can be held between field capacity and the moisture content at which plant growth ceases.

Bleaching:
The near-white colouration of an A_2 horizon which has been subject to chemical depletion as a result of soil-forming processes including eluviation. The colour is defined for all hues as having a value greater than or equal to 7 with a Chroma less than or equal to 4 on dry soils. Conspicuous bleaching means that > 80% of the horizon is bleached whereas sporadic bleaching means that < 80% of the horizon is bleached.

Consistence:
Consistence refers to the strength of cohesion and adhesion in soil. Strength will vary according to soil water status.

Dispersibility:

Value (Emerson)	Interpretation
E6, E7, E8	Very low
E3(1), E3(2), E4, E5	Low
E3(3), E3(4)	Moderate
E2	High
E1	Very high

Drainage:
Drainage is a term used to summarise local soil wetness conditions. It is affected by internal attributes which include soil structure, texture, porosity, hydraulic conductivity, water holding capacity, and external attributes such as evapotranspiration, gradient and length of slope and position in the landscape.

Categories are as follows: Very poorly drained: Free water remains at or near the surface for most of the year. Soils are usually strongly gleyed. Typically a level or depressed site and/or a clayey subsoil.

Poorly drained: All soil horizons remain wet for several months each year. Soils are usually gleyed, strongly mottled and/or have orange or rusty linings of root channels.

Imperfectly drained: Some soil horizons remain wet for periods of several weeks. Subsoils are often mottled and may have orange or rusty linings of root channels.

Moderately well-drained: Some soils may remain wet for a week after water addition. Soils are often whole coloured, but may be mottled at depth and of medium to clayey texture.
Well-drained: No horizon remains wet for more than a few hours after water addition. Soils are usually of medium texture and not mottled.

Rapidly drained: No horizon remains wet except shortly after water addition. Soils are usually of coarse texture, or shallow, or both, and are not mottled.

Duplex soil:
A soil in which there is a sharp change in soil texture between the A and B horizons (such as loam overlying clay).

The soil profile is dominated by the mineral fraction with a texture contrast of 1.5 soil texture groups or greater between the A and B horizons. Horizon boundaries are clear to sharp.

Electrical conductivity (EC):
A measure of the conductivity of electricity through a 1:5 soil water suspension. It is used to determine the soluble salts in the extract. The unit of electrical conductivity is the 'Siemens' and soil salinity is expressed here as decisiemens per metre at 25^{o}C.

Value range (dS/m)	Interpretation
< 0.30	Very low
0.30 - 0.53	Low
0.53 - 1.26	Moderate
1.26 - 2.50	High
> 2.50	Very high

Flooding:
Includes overbank flow from streams and overland-channel flow along drainage depressions.

Gradational soil:
A soil in which there is a gradual change in soil texture between the A and B horizons (for example, loam over clay loam over light clay). The soil is dominated by the mineral fraction and shows more clayey texture grades on passing down the solum of such an order that the texture of each successive horizon changes gradually to that of the one below. Horizon boundaries are usually gradual or diffuse. The texture difference between consecutive horizons is less than 1.5 soil texture groups, while the range of texture throughout the solum exceeds the equivalent span of one texture group.

Gully erosion:
Erosion of soil or soft rock material by running water that forms channels larger and deeper than rills (i.e. 300 mm).

Hardpan:
A hardened and/or cemented horizon, or part thereof, in the soil profile. The hardness is caused by mechanical compaction or cementation of soil particles with organic matter or with materials such as silica, sesquioxides or calcium carbonate. Such pans

frequently reduce soil permeability and root penetration, and thus may give rise to plant growth and drainage problems.

Land capability assessment:
A systematic and rational method of determining the relative ability of different areas of land to sustain a specific land use under a nominated level of management without being degraded or causing any long term off-site degradation.

Land units or components:
An area of land, distinct from adjacent units or components because of specific slope, soil, or geomorphological characteristics, e.g. crest, lower slope.

Land pattern/system:
An area of land, distinct from surrounding terrain, that has a specific climatic range, parent material and modal slope. Made up of a recurring sequence of land elements or components, e.g. sedimentary rolling hills.

Linear shrinkage:
See Shrink/swell potential.

Mottling:
Irregular patches of colour interspersed with and different from the dominant soil colour, that vary in number and size. Mottling can indicate impeded drainage but may also be a result of parent material weathering.

Nutrient status:
Sum of exchangeable base cations (Ca, Mg, K)

Value range (meq/100g)	Interpretation
< 4	Very low
4 - 8	Low
9 - 18	Moderate
19 - 30	High
> 30	Very high

Organic matter:
All constituents of the soil arising from living matter i.e. plant and microfauna detritus, fresh or decomposed. The following values for organic matter have been used in this report:

Value range (%)	Interpretation
< 1	Very low
1 - 2	Low
2 - 3	Moderate
> 3	High

(***** indicates estimated value)
(organic matter % = organic C% x 1.72)

Parent material/rock:
The geologic material from which a soil profile develops. It may be bed-rock or unconsolidated materials including alluvium, colluvium, aeolian deposits or other sediments.

Permeability:
The characteristic of a soil, soil horizon or soil material which governs the rate at which water moves through it. It is a composite expression of soil properties and depends largely on soil texture, soil structure, the presence of compacted or dense soil horizons and the size and distribution of pores in the soil. In this study, the permeability has been measured as K_{sat} (saturated hydraulic conductivity). Where estimates have been made, based on the properties of the soil profile, this is clearly indicated.

Value range (mm/day)	Interpretation
< 10	Very slow
10 - 100	Slow
100 - 500	Moderate
500 - 1500	Rapid
1500 - 3000	Very rapid
> 3000	Excessive

pH (soil reaction):
A measure of the acidity or alkalinity of a soil. A pH (H_2O) of 7.0 denotes neutrality, higher values indicate alkalinity and lower values indicate acidity. Strictly, it represents the negative logarithm of the hydrogen ion concentration in a specified 1:5 soil water suspension on a scale of 0 to 14. Soil pH (H_2O) levels generally fall between 5.5 and 8.0 with most plants growing best in this range.

Phosphorus (P):
Deficient when less than 6 µg/g

Plasticity index:
The plasticity index of a soil is the numerical difference between the plastic limit and the liquid limit.

Potassium (K):

K deficiency
Light textures < 80 µg/g
Medium textures < 110 µg/g
Heavy textures < 120 µg/g

Marginal levels of K
Light textures 80-120 µg/g
Medium textures 110-160 µg/g
Heavy textures 120-180 µg/g

Rill erosion:
Erosion by small channels less than 300 mm deep which can be completely smoothed by normal cultivation.

Recharge:
Movement of surface water down into the underlying groundwaters.

Rock outcrop:
Any exposed area of rock that is inferred to be continuous with the underlying parent material.

Sheet erosion/sheet wash:
The relatively uniform removal of soil from an area without the development of conspicuous channels.

Shrink/swell potential:
The capacity of soil material to change volume with changes in moisture content, frequently measured by a laboratory assessment of the soil's linear shrinkage. It relates to the soil's content of montmorillonite type clays. High shrink swell potential in soils, such as cracking clays, can give rise to problems in earth foundations and soil conservation structures.

Categories used are:

Shrink/swell potent. (%)	Linear shrinkage
0 - 6	Very low
7 - 12	Low
13 - 17	Medium
18 - 22	High
> 22	Very high

Slaking:
The partial breakdown of soil aggregates in water due to the swelling of clay and the expulsion of air from pore spaces. It is a component, along with soil dispersion and soil detachment, of the process whereby soil structure is broken down in the field.

Slope:
Landform element that is neither a crest or a depression and that has an inclination greater than 1%. Slope can be broken up into the following categories:

Value range (%)	Interpretation
< 1%	Level
1 - 3%	Very gentle slope
4 - 10%	Gentle slope
11 - 20%	Moderate slope
21 - 32%	Moderately steep slope
> 32%	Steep slope

Soil colour:
Determined by comparison with a standard Munsell soil colour chart or its equivalent. It includes three variables of colour; hue, value and chroma.

Soil horizon:
A layer within the soil profile with distinct morphological characteristics which are different from the layers above and/or below. Horizons are more or less parallel to the land surface, except that tongues of material from one horizon may penetrate neighbouring horizons.

Soil profile:
A portion of a soil exposed in a vertical section, extending usually from the land surface to the parent material. In very general terms, a profile is made of three major layers designated A, B and C horizons. The A and B horizons are those modified by soil development. The C horizon is weathering parent material that has not yet been significantly altered by soil forming processes.

Soil texture:
The relative proportions of sand, silt and clay particles in a sample of soil. The field assessment of texture is based on the characteristics of a bolus of wetted soil moulded by hand. Six main soil texture groups are recognised
Texture group Approx. clay content

1. Sands < 10%

2. Sandy loams 10 - 20%

3. Loams 20 - 30%

4. Clay loams 30 - 35%

5. Light clays 35 - 40%

6. Heavy clays > 45%

Unified soil group:
A soil classification system based on the identification of soil materials according to their particle size, grading, plasticity index and liquid limit. These properties have been correlated with the engineering behaviour of soils including soil compressibility and shear strength. The system is used to determine the suitability of soil materials for use in earthworks, optimal conditions for their construction, special precautions which may be needed, such as soil ameliorates, and final batter grades to be used to ensure stability.

GW: Well graded gravels, gravel-sand mixtures GP: Poorly graded gravels, gravel-sand mixtures

GM:	Silty gravels, poorly graded gravel-sand-silt mixtures
GC:	Clayey gravels, poorly graded gravel-sand-clay mixtures
SW:	Well graded sands
SP:	Poorly graded sands
SM:	Silty sands, poorly graded sand-silt mixtures
SC:	Clayey sands, poorly graded sand-clay mixtures
ML:	Inorganic silts and very fine sands, clayey fine sands with slight plasticity
CL:	Inorganic clays of low to medium plasticity, sandy clays, silty clays
OL:	Organic silts or organic silt-clays of low plasticity
MH:	Inorganic silts, micaceous fine sandy or silty soils
CH:	Inorganic clays of high plasticity
OH:	Organic clays of moderate to high plasticity
Pt:	Peat

Uniform soil:
A soil in which there is little, if any change in soil texture between the A and B horizons (for example, loam over loam, sandy clay over silty clay). The soil is dominated by the mineral fraction and shows minimal texture difference throughout, such that no clearly defined texture boundaries are to be found. The range of texture throughout the solum is not more than the equivalent span of one soil texture group.